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A LOGICAL ENGINEERING DEGREE [1]

BY O. M. LELAND,

President of the Society.

The data presented by the Board of Investigation and Coordination relative to the history and present practice among engineering schools in the designation of their degrees would seem to clearly justify the conclusion that "the present situation is not a satisfactory one, particularly when compared with that in other major professions." [2]

A brief consideration of the first degrees that are given for the completion of engineering courses at different institutions reveals a variation in practice which fails to be surprising only because it is familiar to us. In many of our colleges, several different forms of degrees have been granted for the same kind of courses. It is not unusual to find that, for the four-year course in civil engineering, for example,[3] the degree C.E. was given at one time, B.S. at another, B.C.E. at a third, and B.S. in C.E. at a fourth period. Sometimes, the order is different, but this is a fair example of the history of the Bachelor's degree in engineering at a single school. What may seem more curious is the fact that at a certain institution, at the present time, a four-year course in civil engineering leads to the degree of B.S. in C.E., while the four-year course in mines, having the same entrance requirements, leads to the degree of E.M. In another case, the four-year course in civil engineering leads to the degree of C.E., while the five-year course in Architecture leads to the degree of B.Arch.

[1] From a paper presented by the author before the Engineering Section of the Association of Land Grant Colleges and Universities at Washington, D. C., November 16, 1926.

[2] Bulletin No. 7 of the Investigation of Engineering Education, November, 1926.

[3] In this article, civil engineering will be used to represent the customary separate courses, civil, electrical, mechanical, etc.

The subject of degrees has been before the engineering schools for at least half a century. It was one of the first subjects actively discussed by the Society for the Promotion of Engineering Education after its organization in 1893.[4] Committees on degrees made elaborate studies and submitted recommendations. These showed, in every case, a large majority in favor of uniform degrees for engineering courses. The report of the committee in 1910 was approved by the Society at its annual convention, advocating the adoption of the degree B.S. with special designation, for example, B.S. in C.E., with a corresponding Master's degree. This action has not been rescinded. On the other hand, it has not resulted in much agreement among the schools, although a few changes seem to have been made in accordance with this policy. In 1925, the degrees B.A. and B.S., without specific, or even general, designation, were conferred by 32 institutions at the completion of four-year engineering courses.

Although we maintain among ourselves, that uniformity of procedure among engineering schools is neither desirable nor anticipated, still there are some phases of our practice about which there might well be a closer agreement. The degree given at the end of the usual four-year course in engineering is one point upon which the great majority of engineering schools could agree, provided there seemed to be a logical basis for the degree to be adopted. It is the purpose of this paper to suggest such a degree.

In American colleges and universities, the practice is almost universal of awarding some kind of a Bachelor's degree for the completion of the usual four-year curriculum. This policy is so firmly grounded that, in a five- or six-year course, the completion of the first four years usually results in a Bachelor's degree. In a five-year combination course composed of two or three years in an academic college, followed by a similar period in the engineering school, the unqualified degree B.S. is frequently given at the completion of the first four years, and the engineering degree of B.S. in C.E., for

[4] See PROC. S. P. E. E., 1894, 1895, 1906, 1910, 1918, and 1920.

example, at the completion of the fifth year. Such Bachelor's degrees, however, are not different in principle from those for the usual academic four-year courses. I think most of us would agree that, since the usual engineering course is of four years' duration, some kind of a Bachelor's degree, that is, one in which the word "Bachelor" occurs, could logically be used. This part of the degree, at least, may be regarded as acceptable to the great majority of engineering faculties, as it is our present practice.

This brings me to the point of my proposal, which deals with the portion of the Bachelor's degree referring to the specific course pursued by the student, or the profession to which the particular curriculum completed by the student is devoted. In brief, my suggestion is that we deliberately abandon the practice which has come down to us from the past, namely, of utilizing the *academic* degrees of Bachelor of Arts and Bachelor of Science, with or without an appendage to indicate the engineering course. We have inherited this from an age when the degree B.A. was given for every college course or when the subsequent modification of B.S. was given for a course in which scientific subjects predominated, instead of the classic languages or social studies.

It is quite customary to give the B.S. degree for all kinds of courses which may be branded as scientific or even, perhaps, as objective, or practical, as distinguished, in some places at least, from the B.A. degree, which is reserved for so-called academic or cultural courses. Thus, we find the degree of Bachelor of Science given for courses in preventive medicine and public health, medical technique, social and civic work, home economics, agriculture, forestry, etc. Similarly, we find the degree B.S. coupled with the special designation of the course taken, as Bachelor of Science in Chemistry, in Agriculture, in Business, in Music, in Interior Decoration, etc. The first four years of a seven-year course in medicine leads to the degree of Bachelor of Science, and perhaps appropriately so.

Specifically, it is suggested that, while the "Bachelor" portion of the degree is retained, the general term "Science"

be replaced by the designation of the profession to which the particular curriculum corresponds. This results in the degrees, B.C.E. (Bachelor of Civil Engineering), B.Arch. (Bachelor of Architecture), B.Agr. (Bachelor of Agriculture), B.E.M. (Bachelor of Mining Engineering), B.Ch.E. (Bachelor of Chemical Engineering), B.Chem. (Bachelor of Chemistry), etc. The underlying principle of this plan is obviously that the *course* taken is, in reality, a *professional course,* and not merely an academic course in which a limited amount of specialization has been followed in some field of applied science.

Our present-day engineering courses are professional in character. The various branches of engineering are professions,—not merely branches of a profession. Civil engineering is a distinct profession,—distinct from chemical engineering or electrical engineering. This distinction is universally recognized. We clearly accept it in our designation of the curricula in our engineering colleges. In most cases, employers requesting young graduates specify the courses in which they have been prepared. Why should we continue to burden our professional engineering students with the academic brand of general science as if the civil engineering portion of the scientific course still consisted of a few hours of surveying, with a little mechanics and hydraulics? Although this may have been true many years ago, it does not correspond to present curricula. Is it not possible that by the label we place upon them we may fail to inculcate in our students the respect for their professions which they should have?

It will be readily observed that this plan may amount to a step backward in the history of some of our institutions at which the degree of B.C.E. once given has been replaced by B.S., B.S. in C.E., or C.E. Has not the basis for the recommendation of the committee in 1910 been modified by changes in the professional character of the engineering courses, or, perhaps, by the advancement and recognition of the engineering professions?

In so far as it is possible, a degree should convey a definite

meaning to those who are familiar with college education. The meaning of the degree B.S., as now used, is not evident. At least, it does not conform to its original conception, which was that it marked the completion of a course in general scientific subjects. At present, it is frequently qualified by some specific designation of the course pursued. This qualification may be shown in full on the diploma of the recipient but, in most cases, for example when it is written after a person's name, only the letters B.S. are used. In fact, when the recipient is asked what degree he received, rather than give a long explanation, he often replies briefly, "B.S." That degree does not represent, in the case of engineering graduates at least, the professional course pursued. In that respect, it is unsatisfactory, and fails to accomplish its purpose. The degree B.C.E. does represent the completion of a course of study in a certain professional line, namely, civil engineering. It avoids the indefiniteness and unnecessary generality of the word "science," which is replaced by a clearly defined and recognized profession.

Questions as between the general degree B.E. or B.Tech. and the separate degrees, B.C.E., B.M.E., etc., are foreign to this discussion. All of these conform to the suggested principle that the logical Bachelor's degree for a professional course should consist of the word "Bachelor" followed by the *name of the profession*, without the word "science" or "arts." It would apply to any recognized profession. It corresponds, for example, to the accepted Bachelor's degree in law, which is L.L.B. and not A.B. or A.B. in law.

Another angle from which the Bachelor's degree in engineering should be considered is that of the advanced degree which follows it. There should be a consistent relationship among the degrees in a certain specialty or profession. The degree B.C.E. possesses this advantage as well as B.S. in C.E. or merely B.S. Certainly, it is much to be preferred, in this respect, to C.E., which is still given by a few institutions for the completion of a four-year course. The degree M.C.E. (Master of Civil Engineering) is used as a graduate degree

for those whose first degree is C.E. This, obviously, is inconsistent with the common idea that C.E. represents a higher engineering degree than the Master's and involves experience in the practice of the profession. However, M.C.E. as a Master's degree in civil engineering is a logical graduate degree to follow B.C.E. The degrees M.S. and M.S. in C.E. are as objectionable as B.S. in C.E., and for similar reasons.

The objection to the B.C.E. type of degree may be raised that it includes three letters, instead of two and, therefore, may appear clumsy. To this, the reply may be that many degrees in other professions now contain three letters, such as D.D.S. (Doctor of Dental Surgery), D.V.M. (Doctor of Veterinary Medicine), and B.L.A. (Bachelor of Landscape Architecture). But the logical answer is that B.S. does not convey the meaning that B.C.E. conveys. In order to obtain this distinctive meaning, the degree B.S. in C.E. is now used and this includes at least four letters, instead of three. The objection to the three-letter degree should not be serious when its advantages over B.S. and B.S. in C.E. are considered.

It would seem that the advantages of the B.C.E. type, as compared with the B.S. in C.E. might be generally recognized, and that there would be a stronger reason to hope for unanimity of action on this basis than upon the latter. The B.C.E. degree is at present used by some institutions; it has been used in the past by various other schools which modified it, possibly in accordance with the recommendation of the S. P. E. E. committee. One of the disadvantages in the consideration of degrees in the past seems to have been the endeavor to force the engineering degrees into one of the established, purely academic forms. If engineering degrees are to be distinctive and representative, we must give them a professional character, rather than a purely academic one.

Certainly, if we all feel that our engineering degrees should be placed upon some kind of a uniform basis, we ought to be able to devise a satisfactory plan. By no means does this carry the idea of standardized curricula or courses of instruction, or quality of teachers, or other of the variables among

our colleges. Although medical and law curricula are not uniform, at least their degrees do not show the variation that engineering degrees show. On the other hand, we have gradually reached a fairly uniform basis for admission. Our entrance requirements are in fair agreement. The degree would seem to be another point where the engineering schools ought to be able to get together on a common ground, as a matter of professional or economic understanding.

A STUDY OF ENGINEERING CURRICULA *

BY WALTON C. JOHN,

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Purposes.—This study deals with the requirements for entrance and for graduation in the colleges which grant first degrees in engineering. The five curricula of widest occurrence and largest enrollment are included, namely: Civil, mining, mechanical, electrical and chemical engineering. The treatment is primarily quantitative and aims to indicate what is taught and in what proportions rather than what should be taught. Under given conditions it may be shown that the lengthening of the course of study or the expansion of the curriculum may make possible marked improvement in the quality of education, and on the other hand there are examples indicating that reduction may be made in total or specific requirements and make more efficient work possible under the circumstances. Thus it appears that the quantitative and the qualitative aspects of the matter cannot readily be dissociated.

It is hoped that the facts thus organized may assist the curriculum maker in arriving at necessary readjustments, whether by lengthening or shortening courses of study, by improving their coordination or by making more logical their sequences.

Plan of Presentation.—The present study exhibits both entrance requirements and curricula as analyzed into groups of closely related subject matter under the following heads: English, mathematics, physical sciences, social sciences, foreign languages, physical and military training, miscellaneous non-engineering subjects, non-engineering electives, the principal engineering subject of the particular curriculum, other engineering subjects, and engineering electives. The require-

* Bulletin Number 10 of the Investigation of Engineering Education. Copyright, 1926, by the Society for the Promotion of Engineering Education. Contents may be quoted with reference to the source.

ments are shown for individual institutions, together with maximum, minimum and median figures and with an indication of distribution and of modal tendencies. Part I presents in graphic form the combined requirements for the eight-year period of preparation and instruction under direct and indirect control of the colleges of engineering. Average figures are given for both publicly and privately controlled institutions. Part II is a comparative summary and analysis of graduation requirements in the five curricula studied, together with a comparison of engineering curricula with curricula in agriculture. Part III is a summary and a detailed analysis of entrance requirements. Part IV comprises the detailed analysis of graduation requirements in the several curricula by institutions. The more general features of the study are covered in Parts I and II.

Scope.—Ninety-two colleges which award first degrees in engineering are included in one or more features of the study. All are located in the United State. Sixty of these institutions are under public control and thirty-two are under private control. The group as a whole includes slightly more than sixty per cent of all the colleges of this type in the United States and is believed to be quite representative within the range of normal conditions. The complete list of colleges included is given in the JOURNAL OF ENGINEERING EDUCATION, April, 1926, pp. 523–525 inc.

The analysis of entrance requirements includes all the institutions in this list. It was found necessary, however, to omit from the analyses of graduation requirements a few institutions for which the data can not readily be made to correspond to the data for the group as a whole. Thus, the University of Cincinnati, the University of North Carolina and the Municipal University of Akron are omitted because of the cooperative plan on which their curricula are organized; while Rensselaer Polytechnic Institute and Worcester Polytechnic Institute are omitted because of difficulty in reducing their graduation requirements to semester-hour credits. Not all of the remaining eighty-seven institutions offer all of the cur-

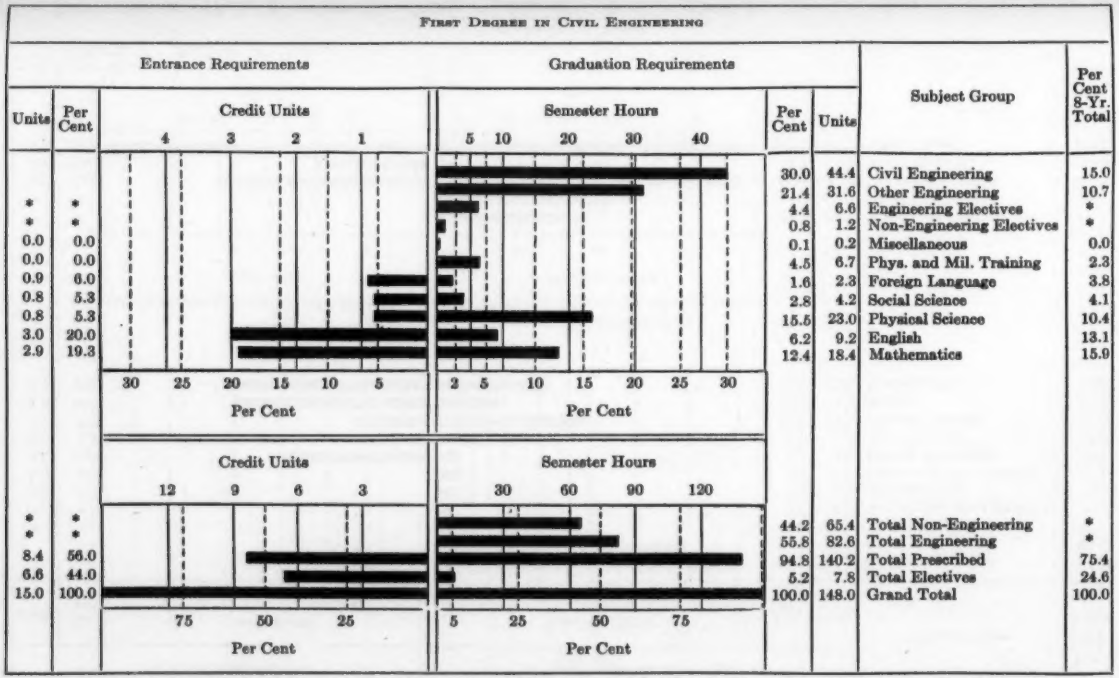
ricula studied. The net result is that the analysis of the civil engineering curriculum is based on eighty-three institutions, the mining engineering curriculum on twenty-five, the mechanical engineering curriculum on seventy-six, the electrical engineering curriculum on seventy-eight, and the chemical engineering curriculum on fifty-five. The data for several colleges which operate on a quarter basis have been reduced to equivalent semester-hours.

Sources of Information.—The primary data were taken from the catalogs of the several institutions for the academic year of 1924–25 and were checked in most cases by the deans or the registrars. In some instances where verification was not obtainable the author was able to include the information desired because of the clear statements of the catalogs.

PART I. GRAPHICAL SUMMARIES OF COMBINED REQUIREMENTS FOR ADMISSION AND FOR GRADUATION

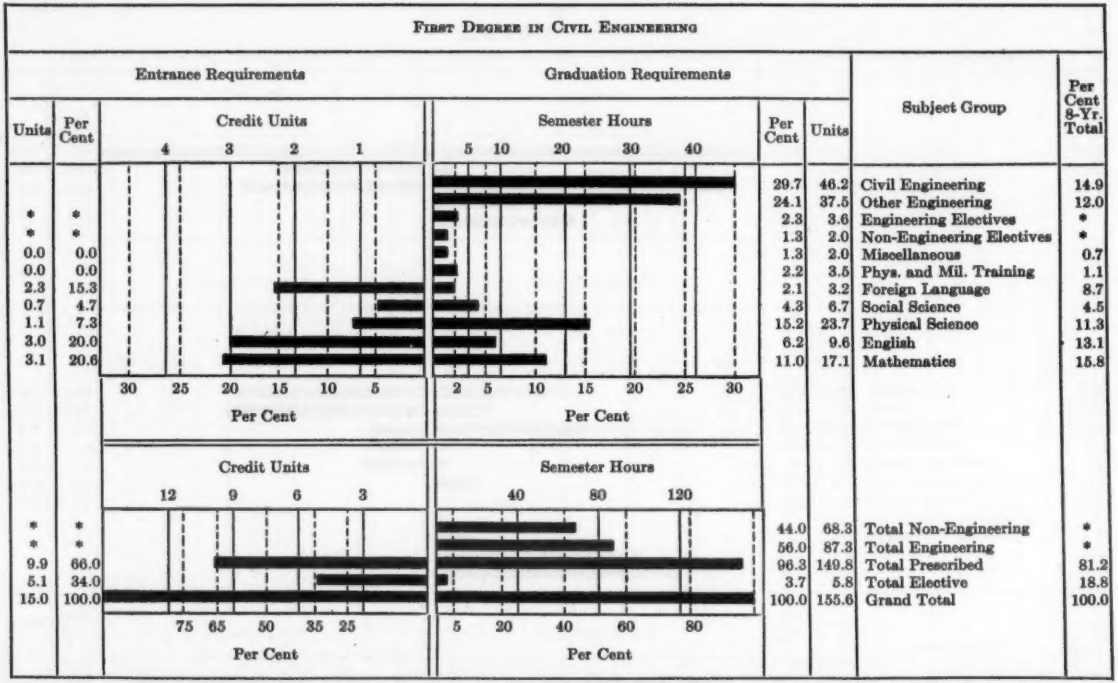
Relations Shown.—The following series of graphs brings together the principal features of the analyses of both groups of requirements in two sets of general pictures, one set for the publicly controlled and the other for the privately controlled institutions. The data shown to the left of the central division of each chart are the average entrance requirements, expressed both in high school units and as percentages of the total. The data immediately to the right of the central division are the average graduation requirements, expressed in semester-hour units and as percentages of the total. At the extreme right are shown the combined entrance and graduation requirements expressed as percentages of the total for the eight-year period directly and indirectly under the control of the engineering colleges.

The graphs *A* to *J* inclusive therefore show the relation of the various requirements by groups, from the standpoint of the four-year high school period, the four-year college period, and in combination, the entire period of eight years. For convenience different scales are used for the individual items and for the totals.


First Degree in Civil Engineering
Entrance Requirements
Graduation Requirements
Units
Per Cent
Credit Units
4 3 2 1
Semester Hours
5 10 20 30 40
Per Cent
Units
Subject Group
Per Cent 8-Yr. Total
30 25 20 15 10 5
Per Cent
2 5 10 15 20 25 30
Per Cent
12 9 6 3
30 60 90 120
75 50 25
Per Cent
5 25 50 75
Per Cent
* * Civil Engineering 15.0
* * Other Engineering 10.7
0.0 0.0 Engineering Electives *
0.0 0.0 Non-Engineering Electives *
0.9 6.0 Miscellaneous 0.0
0.8 5.3 Phys. and Mil. Training 2.3
0.8 5.3 Foreign Language 3.8
3.0 20.0 Social Science 4.1
2.9 19.3 Physical Science 10.4
English 13.1
Mathematics 15.9
* * 30.0 44.4 Civil Engineering
* * 21.4 31.6 Other Engineering
4.4 6.6 Engineering Electives
0.8 1.2 Non-Engineering Electives
0.1 0.2 Miscellaneous
4.5 6.7 Phys. and Mil. Training
1.6 2.3 Foreign Language
2.8 4.2 Social Science
15.5 23.0 Physical Science
6.2 9.2 English
12.4 18.4 Mathematics
* * 44.2 65.4 Total Non-Engineering *
* * 55.8 82.6 Total Engineering *
8.4 56.0 94.8 140.2 Total Prescribed 75.4
6.6 44.0 5.2 7.8 Total Electives 24.6
15.0 100.0 100.0 148.0 Grand Total 100.0

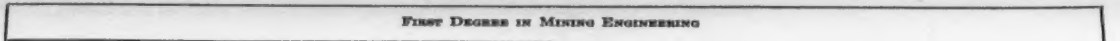
GRAPH A. Analysis of Average Requirements for Entrance and for Graduation, Civil Engineering Curricula of 55 Public Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.


First Degree in Civil Engineering
Entrance Requirements
Graduation Requirements
Units
Per Cent
Credit Units
4 3 2 1
Semester Hours
5 10 20 30 40
Per Cent
Units
Subject Group
Per Cent 8-Yr. Total
30 25 20 15 10 5
Per Cent
2 5 10 15 20 25 30
Per Cent
Credit Units
12 9 6 3
Semester Hours
40 80 120
75 65 50 35 25
Per Cent
5 20 40 60 80
Per Cent
* * * * 0.0 0.0 2.3 15.3 0.7 4.7 1.1 7.3 3.0 20.0 3.1 20.6
29.7 46.2 Civil Engineering 14.9
24.1 37.5 Other Engineering 12.0
2.3 3.6 Engineering Electives *
1.3 2.0 Non-Engineering Electives *
1.3 2.0 Miscellaneous 0.7
2.2 3.5 Phys. and Mil. Training 1.1
2.1 3.2 Foreign Language 8.7
4.3 6.7 Social Science 4.5
15.2 23.7 Physical Science 11.3
6.2 9.6 English 13.1
11.0 17.1 Mathematics 15.8
* * * * 9.9 66.0 5.1 34.0 15.0 100.0
44.0 68.3 Total Non-Engineering *
56.0 87.3 Total Engineering *
96.3 149.8 Total Prescribed 81.2
3.7 5.8 Total Elective 18.8
100.0 155.6 Grand Total 100.0

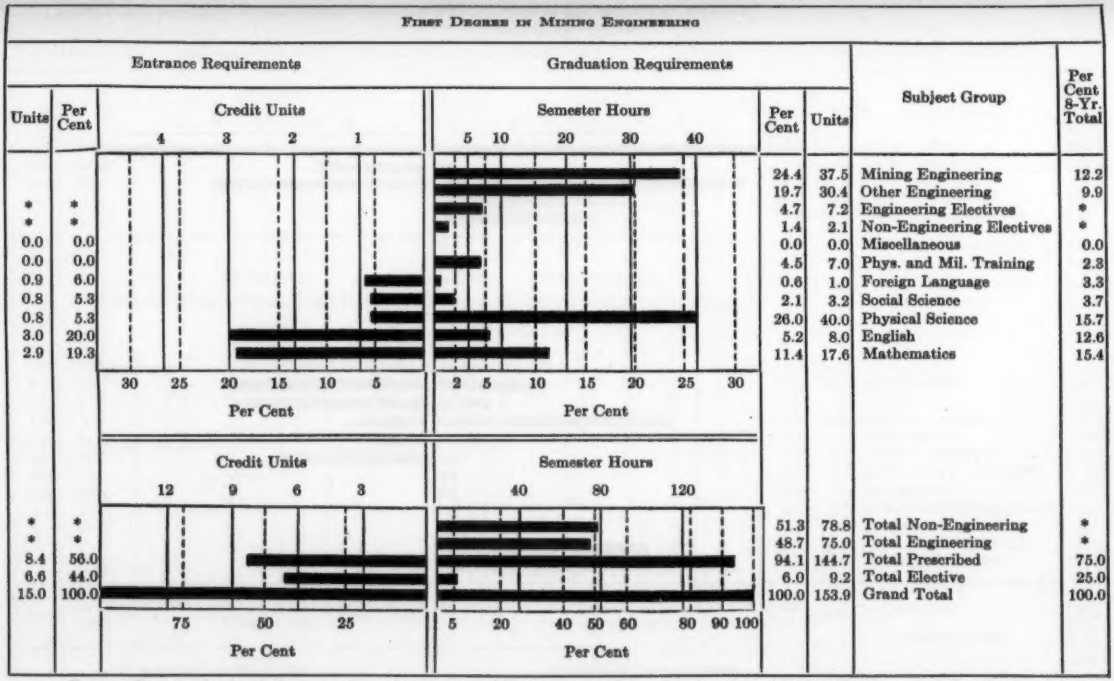
Graph B. Analysis of Average Requirements for Entrance and for Graduation, Civil Engineering Curricula of 28 Private Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.



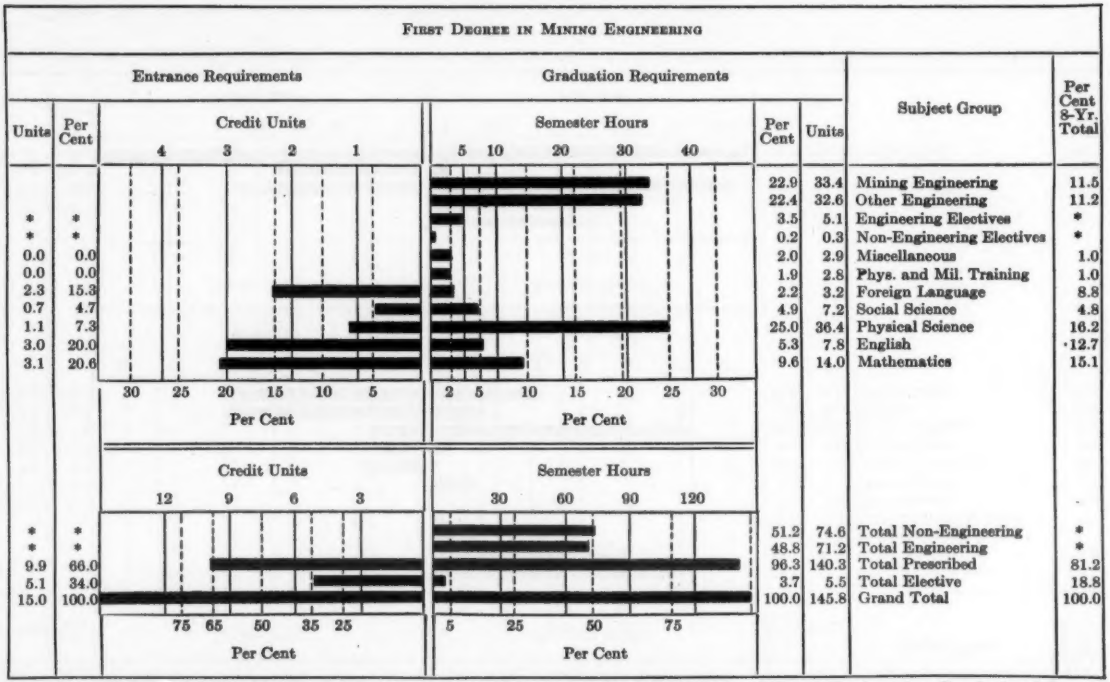
Private Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.


First Degree in Mining Engineering
Entrance Requirements
Graduation Requirements
Units
Per Cent
Credit Units
4 3 2 1
Semester Hours
5 10 20 30 40
Per Cent
Units
Subject Group
Per Cent 8-Yr. Total
* * 24.4 37.5 Mining Engineering 12.2
* * 19.7 30.4 Other Engineering 9.9
4.7 7.2 Engineering Electives *
1.4 2.1 Non-Engineering Electives *
0.0 0.0 0.0 0.0 Miscellaneous 0.0
0.0 0.0 4.5 7.0 Phys. and Mil. Training 2.3
0.9 6.0 0.6 1.0 Foreign Language 3.3
0.8 5.3 2.1 3.2 Social Science 3.7
0.8 5.3 26.0 40.0 Physical Science 15.7
3.0 20.0 5.2 8.0 English 12.6
2.9 19.3 11.4 17.6 Mathematics 15.4
30 25 20 15 10 5
2 5 10 15 20 25 30
Per Cent
Credit Units
12 9 6 3
Semester Hours
40 80 120
* * 51.3 78.8 Total Non-Engineering *
* * 48.7 75.0 Total Engineering *
8.4 56.0 94.1 144.7 Total Prescribed 75.0
6.6 44.0 6.0 9.2 Total Elective 25.0
15.0 100.0 100.0 153.9 Grand Total 100.0
75 50 25
5 20 40 50 60 80 90 100
Per Cent

Graph C. Analysis of Average Requirements for Entrance and for Graduation, Mining Engineering Curricula of 16 Public Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.

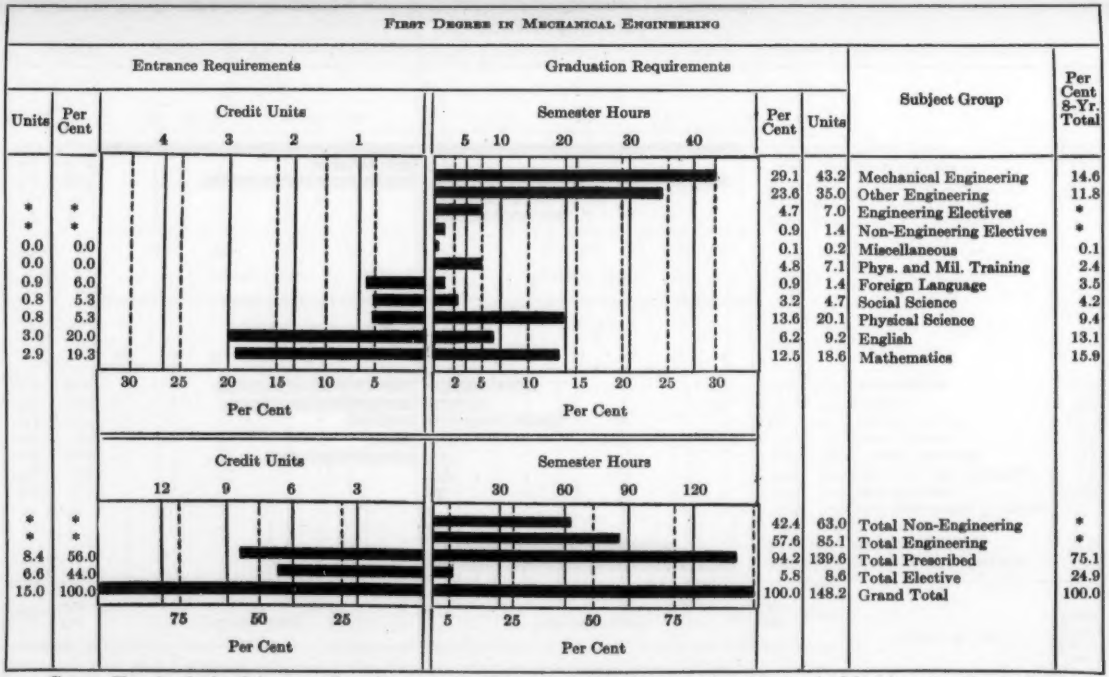

First Degree in Mining Engineering
Entrance Requirements
Graduation Requirements
Units
Per Cent
Credit Units
4 3 2 1
Semester Hours
5 10 20 30 40
Per Cent
Units
Subject Group
Per Cent 8-Yr. Total
* * 22.9 33.4 Mining Engineering 11.5
* * 22.4 32.6 Other Engineering 11.2
* * 3.5 5.1 Engineering Electives *
* * 0.2 0.3 Non-Engineering Electives *
0.0 0.0 2.0 2.9 Miscellaneous 1.0
0.0 0.0 1.9 2.8 Phys. and Mil. Training 1.0
2.3 15.3 2.2 3.2 Foreign Language 8.8
0.7 4.7 4.9 7.2 Social Science 4.8
1.1 7.3 25.0 36.4 Physical Science 16.2
3.0 20.0 5.3 7.8 English 12.7
3.1 20.6 9.6 14.0 Mathematics 15.1
30 25 20 15 10 5
Per Cent
2 5 10 15 20 25 30
Per Cent
Credit Units
12 9 6 3
Semester Hours
30 60 90 120
* * 51.2 74.6 Total Non-Engineering *
* * 48.8 71.2 Total Engineering *
9.9 66.0 96.3 140.3 Total Prescribed 81.2
5.1 34.0 3.7 5.5 Total Elective 18.8
15.0 100.0 100.0 145.8 Grand Total 100.0
75 65 50 35 25
Per Cent
5 25 50 75
Per Cent

GRAPH D. Analysis of Average Requirements for Entrance and for Graduation, Mining Engineering Curricula of 9 Private Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.

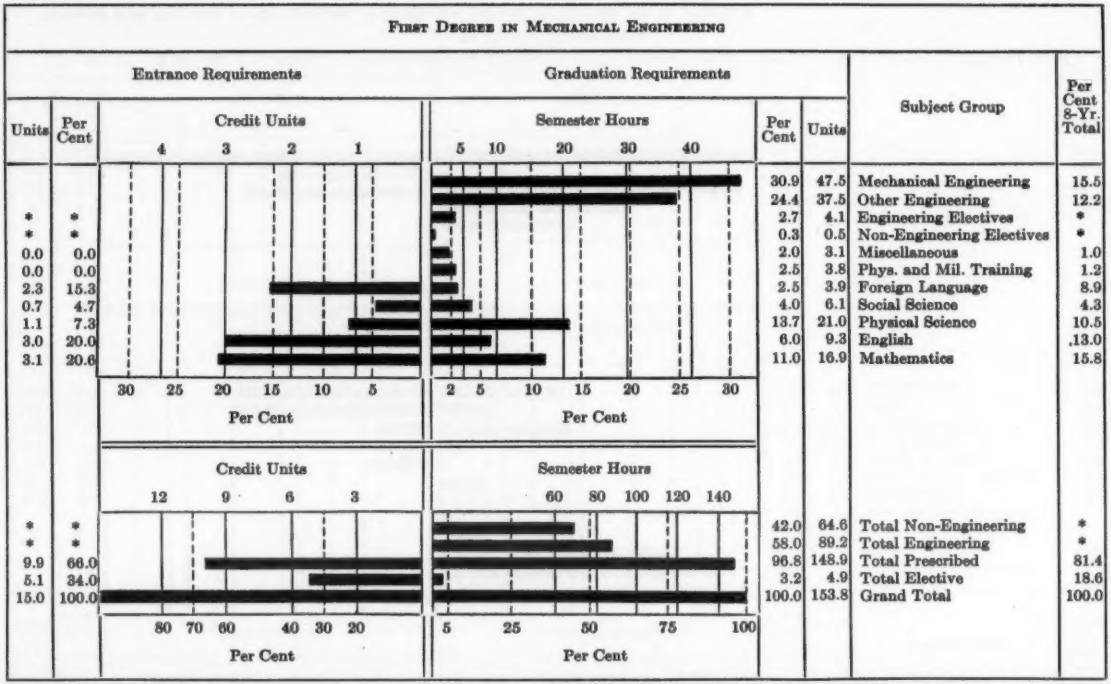
Private Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.


First Degree in Mechanical Engineering
Entrance Requirements
Graduation Requirements
Units
Per Cent
Credit Units
4 3 2 1
Semester Hours
5 10 20 30 40
Per Cent
Units
Subject Group
Per Cent 8-Yr. Total
30 25 20 15 10 5
Per Cent
2 5 10 15 20 25 30
Per Cent
Credit Units
12 9 6 3
Semester Hours
30 60 90 120
75 50 25
Per Cent
5 25 50 75
Per Cent
* * 29.1 43.2 Mechanical Engineering 14.6
* * 23.6 35.0 Other Engineering 11.8
4.7 7.0 Engineering Electives *
0.9 1.4 Non-Engineering Electives *
0.0 0.0 0.1 0.2 Miscellaneous 0.1
0.0 0.0 4.8 7.1 Phys. and Mil. Training 2.4
0.9 6.0 0.9 1.4 Foreign Language 3.5
0.8 5.3 3.2 4.7 Social Science 4.2
0.8 5.3 13.6 20.1 Physical Science 9.4
3.0 20.0 6.2 9.2 English 13.1
2.9 19.3 12.5 18.6 Mathematics 15.9
* * 42.4 63.0 Total Non-Engineering *
* * 57.6 85.1 Total Engineering *
8.4 56.0 94.2 139.6 Total Prescribed 75.1
6.6 44.0 5.8 8.6 Total Elective 24.9
15.0 100.0 100.0 148.2 Grand Total 100.0

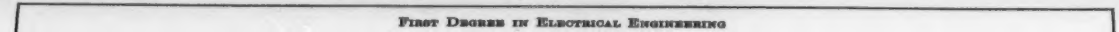
Graph E. Analysis of Average Requirements for Entrance and for Graduation, Mechanical Engineering Curricula of 54 Public Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.


First Degree in Mechanical Engineering
Entrance Requirements
Graduation Requirements
Units
Per Cent
Credit Units
4 3 2 1
Semester Hours
5 10 20 30 40
Per Cent
Units
Subject Group
Per Cent 8-Yr. Total
30 25 20 15 10 5
Per Cent
2 5 10 15 20 25 30
Per Cent
Credit Units
12 9 6 3
Semester Hours
60 80 100 120 140
80 70 60 40 30 20
Per Cent
5 25 50 75 100
Per Cent
* * 30.9 47.5 Mechanical Engineering 15.5
* * 24.4 37.5 Other Engineering 12.2
* * 2.7 4.1 Engineering Electives *
* * 0.3 0.5 Non-Engineering Electives *
0.0 0.0 2.0 3.1 Miscellaneous 1.0
0.0 0.0 2.5 3.8 Phys. and Mil. Training 1.2
2.3 15.3 2.5 3.9 Foreign Language 8.9
0.7 4.7 4.0 6.1 Social Science 4.3
1.1 7.3 13.7 21.0 Physical Science 10.5
3.0 20.0 6.0 9.3 English 13.0
3.1 20.6 11.0 16.9 Mathematics 15.8
* * 42.0 64.6 Total Non-Engineering *
* * 58.0 89.2 Total Engineering *
9.9 66.0 96.8 148.9 Total Prescribed 81.4
5.1 34.0 3.2 4.9 Total Elective 18.6
15.0 100.0 100.0 153.8 Grand Total 100.0

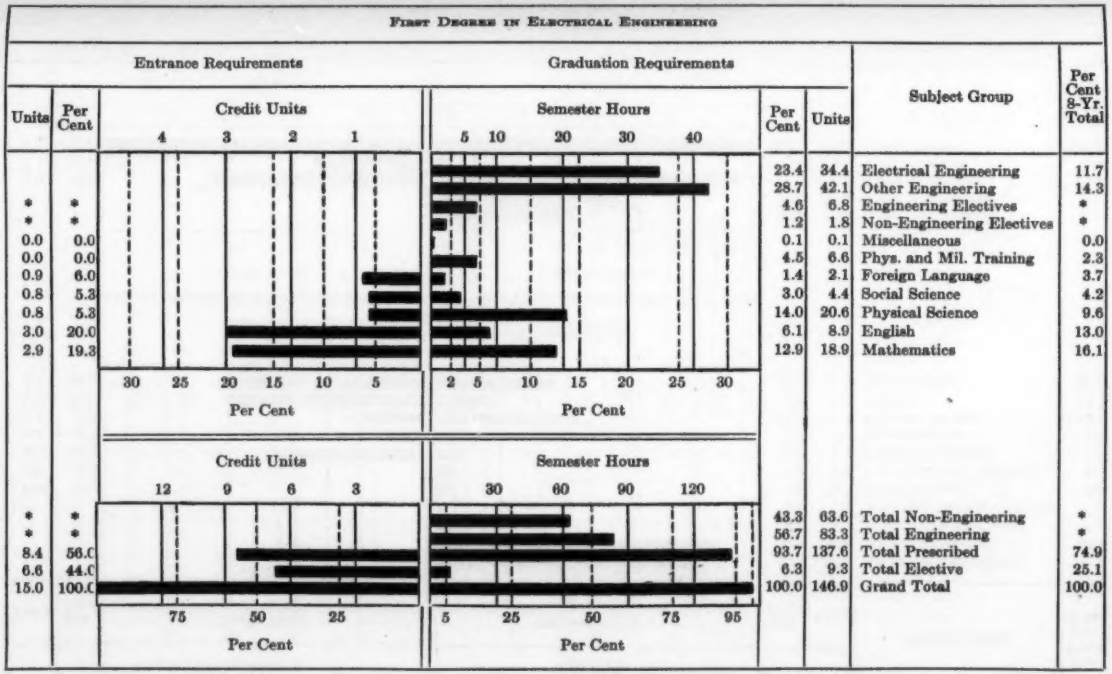
GRAPH F. Analysis of Average Requirements for Entrance and for Graduation, Mechanical Engineering Curricula of 22 Private Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.



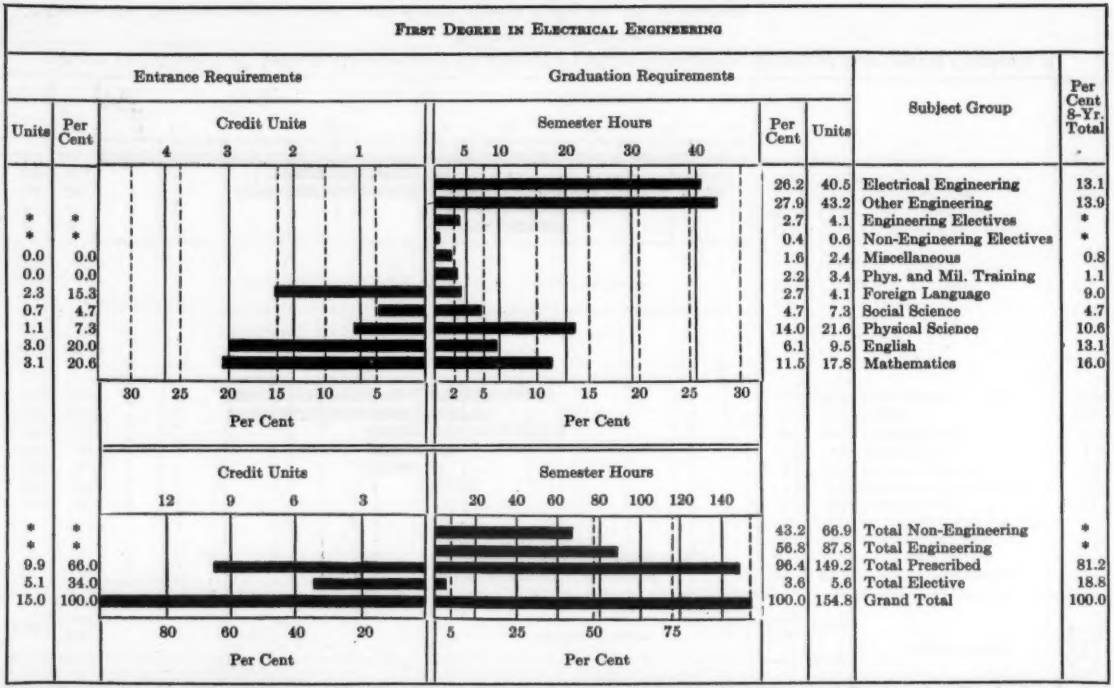
22 Private Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.


First Degree in Electrical Engineering
Entrance Requirements
Graduation Requirements
Units
Per Cent
Credit Units
4 3 2 1
Semester Hours
5 10 20 30 40
Per Cent
Units
Subject Group
Per Cent 8-Yr. Total
30 25 20 15 10 5
Per Cent
2 5 10 15 20 25 30
Per Cent
Credit Units
12 9 6 3
Semester Hours
30 60 90 120
75 50 25
Per Cent
5 25 50 75 95
Per Cent
* * * * 0.0 0.0 0.9 0.8 0.8 3.0 2.9
* * * * 0.0 6.0 5.3 5.3 20.0 19.3
23.4 34.4 Electrical Engineering 11.7
28.7 42.1 Other Engineering 14.3
4.6 6.8 Engineering Electives *
1.2 1.8 Non-Engineering Electives *
0.1 0.1 Miscellaneous 0.0
4.5 6.6 Phys. and Mil. Training 2.3
1.4 2.1 Foreign Language 3.7
3.0 4.4 Social Science 4.2
14.0 20.6 Physical Science 9.6
6.1 8.9 English 13.0
12.9 18.9 Mathematics 16.1
43.3 63.6 Total Non-Engineering *
56.7 83.3 Total Engineering *
93.7 137.6 Total Prescribed 74.9
6.3 9.3 Total Elective 25.1
100.0 146.9 Grand Total 100.0

Graph G. Analysis of Average Requirements for Entrance and for Graduation, Electrical Engineering Curricula of 55 Public Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.

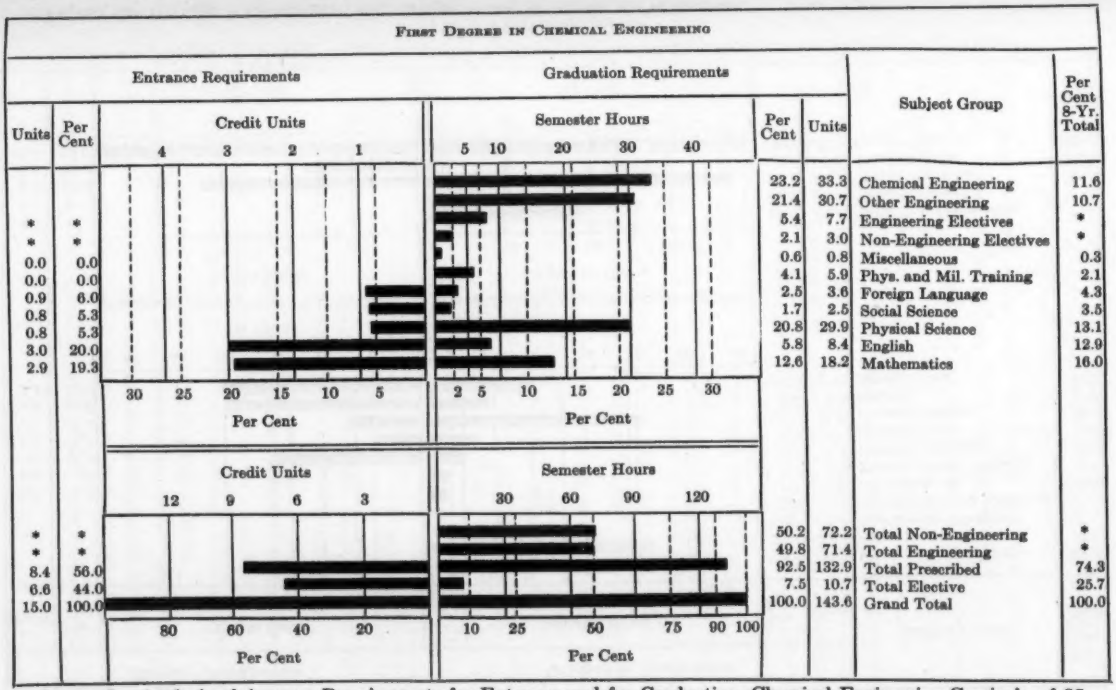

First Degree in Electrical Engineering
Entrance Requirements
Graduation Requirements
Units
Per Cent
Credit Units
4 3 2 1
Semester Hours
5 10 20 30 40
Per Cent
Units
Subject Group
Per Cent 8-Yr. Total
* * 26.2 40.5 Electrical Engineering 13.1
* * 27.9 43.2 Other Engineering 13.9
* * 2.7 4.1 Engineering Electives *
* * 0.4 0.6 Non-Engineering Electives *
0.0 0.0 1.6 2.4 Miscellaneous 0.8
0.0 0.0 2.2 3.4 Phys. and Mil. Training 1.1
2.3 15.3 2.7 4.1 Foreign Language 9.0
0.7 4.7 4.7 7.3 Social Science 4.7
1.1 7.3 14.0 21.6 Physical Science 10.6
3.0 20.0 6.1 9.5 English 13.1
3.1 20.6 11.5 17.8 Mathematics 16.0
30 25 20 15 10 5
Per Cent
2 5 10 15 20 25 30
Per Cent
Credit Units
12 9 6 3
Semester Hours
20 40 60 80 100 120 140
* * 43.2 66.9 Total Non-Engineering *
* * 56.8 87.8 Total Engineering *
9.9 66.0 96.4 149.2 Total Prescribed 81.2
5.1 34.0 3.6 5.6 Total Elective 18.8
15.0 100.0 100.0 154.8 Grand Total 100.0
80 60 40 20
Per Cent
5 25 50 75
Per Cent

GRAPH H. Analysis of Average Requirements for Entrance and for Graduation, Electrical Engineering Curricula of 23 Private Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.

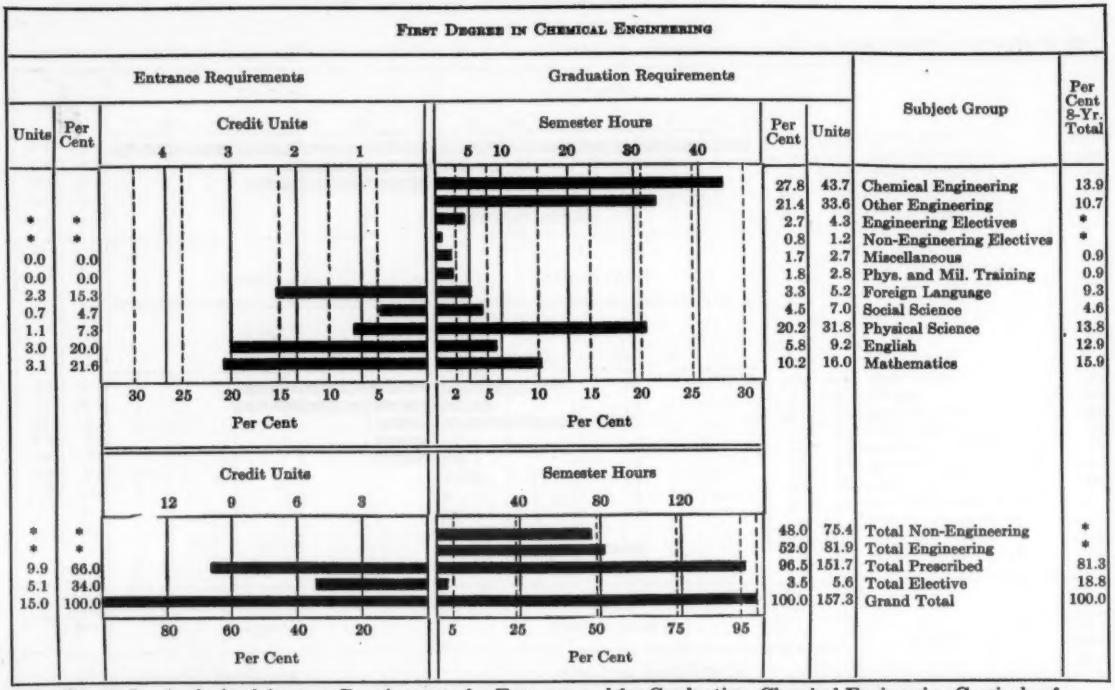
GRAPH H. Analysis of Average Requirements ... 23 Private Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.


First Degree in Chemical Engineering
Entrance Requirements
Graduation Requirements
Units
Per Cent
Credit Units
4 3 2 1
Semester Hours
5 10 20 30 40
Per Cent
Units
Subject Group
Per Cent 8-Yr. Total
* * Chemical Engineering 23.2 33.3 11.6
* * Other Engineering 21.4 30.7 10.7
0.0 0.0 Engineering Electives 5.4 7.7 *
0.0 0.0 Non-Engineering Electives 2.1 3.0 *
0.9 6.0 Miscellaneous 0.6 0.8 0.3
0.8 5.3 Phys. and Mil. Training 4.1 5.9 2.1
0.8 5.3 Foreign Language 2.5 3.6 4.3
3.0 20.0 Social Science 1.7 2.5 3.5
2.9 19.3 Physical Science 20.8 29.9 13.1
30 25 20 15 10 5
2 5 10 15 20 25 30
Per Cent
Per Cent
English 5.8 8.4 12.9
Mathematics 12.6 18.2 16.0
Credit Units
12 9 6 3
Semester Hours
30 60 90 120
* * Total Non-Engineering 50.2 72.2 *
* * Total Engineering 49.8 71.4 *
8.4 56.0 Total Prescribed 92.5 132.9 74.3
6.6 44.0 Total Elective 7.5 10.7 25.7
15.0 100.0 Grand Total 100.0 143.6 100.0
80 60 40 20
10 25 50 75 90 100
Per Cent
Per Cent

GRAPH I. Analysis of Average Requirements for Entrance and for Graduation, Chemical Engineering Curricula of 35 Public Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.


First Degree in Chemical Engineering
Entrance Requirements
Graduation Requirements
Units
Per Cent
Credit Units
4 3 2 1
Semester Hours
5 10 20 30 40
Per Cent
Units
Subject Group
Per Cent 8-Yr. Total
* * 27.8 43.7 Chemical Engineering 13.9
* * 21.4 33.6 Other Engineering 10.7
* * 2.7 4.3 Engineering Electives *
* * 0.8 1.2 Non-Engineering Electives *
0.0 0.0 1.7 2.7 Miscellaneous 0.9
0.0 0.0 1.8 2.8 Phys. and Mil. Training 0.9
2.3 15.3 3.3 5.2 Foreign Language 9.3
0.7 4.7 4.5 7.0 Social Science 4.6
1.1 7.3 20.2 31.8 Physical Science 13.8
3.0 20.0 5.8 9.2 English 12.9
3.1 21.6 10.2 16.0 Mathematics 15.9
30 25 20 15 10 5
Per Cent
2 5 10 15 20 25 30
Per Cent
Credit Units
12 9 6 3
Semester Hours
40 80 120
* * 48.0 75.4 Total Non-Engineering *
* * 52.0 81.9 Total Engineering *
9.9 66.0 96.5 151.7 Total Prescribed 81.3
5.1 34.0 3.5 5.6 Total Elective 18.8
15.0 100.0 100.0 157.3 Grand Total 100.0
80 60 40 20
Per Cent
5 25 50 75 95
Per Cent

Graph J. Analysis of Average Requirements for Entrance and for Graduation, Chemical Engineering Curricula of 20 Private Institutions.

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.

PART II. COMPARATIVE SUMMARY AND ANALYSIS OF GRADUATION REQUIREMENTS IN THE FIVE PRINCIPAL ENGINEERING CURRICULA

Relations Shown.—In order to bring out the points of similarity and of difference between the several curricula examined, certain items from the detailed analyses of graduation requirements given in Part IV have been combined in Table I, entitled "Synthesis of Quantitative Standards of Principal Engineering Curricula," and are shown in graphic form in Figs. 1 to 5 inclusive. As a simple means of indicating both the tendency to adhere to a norm and the extent of the variations found, the respective ranges of the lowest fifth, the middle three-fifths and the highest fifth of the cases included, are indicated in the table and the diagrams.

Similarity of Total Requirements.—It is plain from Table I and from Fig. 1 that both the median requirements and the range of the middle three-fifths of the cases are strikingly alike for the five curricula. These requirements are consist-

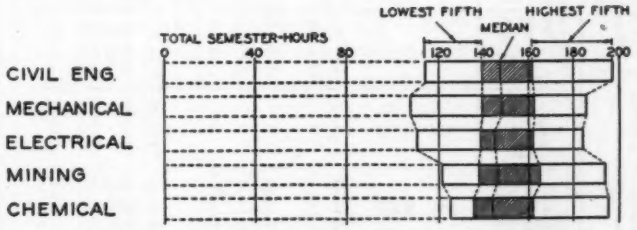


FIG. 1. Range of variation in total semester-hours required for graduation in the five major engineering curricula.

ently large in comparison with undergraduate college requirements in other fields and seem to point to a tendency to make the four-year requirements in engineering approximate in volume to five years on the usual academic scale.

Variations in Group Requirements.—Referring to Fig. 2 and to Table I, it is evident that the mining and chemical engineering curricula are relatively low in the total engineering requirements. This condition is offset, however, by the in-

* Denotes that the value is indeterminate, since elective entrance credits can not be separated.

20 Private Institutions.

TABLE I.

SYNTHESIS OF QUANTITATIVE STANDARDS OF PRINCIPAL ENGINEERING CURRICULA.

Based on studies of curricula in 87 institutions.

	Semester-hour Units.											
	Total Semester-Hours.	Prescribed Engineering.		Engineering Electives.	Non-Engineering Subjects.		Mathematics.	Physical Science.	English.	Social Science.	Foreign Language.	Physical and Military Training.
		Principal Branch.	Other Branches.		Required.	Elective.						
MEDIANS												
Civil Engineering	147	43	33	3	64	0	18	22	10	4	0	4
Mining Engineering	146	34	30	6	75	0	18	38	7	4	0	6
Mechanical Engineering	148	44	36	5	63	0	18	20	10	6	0	6
Electrical Engineering	145	34	42	5	64	0	18	20	8.8	5	0	4
Chemical Engineering	144	37	32	5	72.4	0	18	30	8	3	0	4
LOWEST FIFTH												
Civil Engineering	114 to 139	24 to 35	15 to 26	0	39.4 to 54.6	0	11 to 16.6	8.6 to 18	0 to 6	0	0	0
Mining Engineering	121.3 to 138	10.7 to 28.7	11.4 to 25	0	45 to 65	0	9 to 12	24 to 31.3	0 to 6	0	0	0
Mechanical Engineering	108 to 139.6	22 to 34	17 to 30	0	40.7 to 54	0	12 to 16	12 to 16	0 to 6	0	0	0
Electrical Engineering	111 to 139.3	15 to 27	26 to 33	0	40.7 to 54	0	12 to 16	12 to 16	0 to 6	0	0	0
Chemical Engineering	125 to 136	15 to 26	7.3 to 22.3	0	47 to 62	0	9 to 16	12 to 23	0 to 6	0	0	0
					Total.	Elective.						
HIGHEST FIFTH												
Civil Engineering	161.5 to 196.5	54 to 78	41 to 67	12 to 42	78 to 102	10 to 20	20 to 24	28 to 54	12 to 22	8 to 21	6 to 16	9 to 21.3
Mining Engineering	165 to 194	43 to 62	37 to 49	12 to 24	91.7 to 103.5	3 to 16	20 to 23	47 to 55	10 to 20	8 to 14	6 to 11	8 to 16
Mechanical Engineering	162.5 to 184.7	56 to 72	43 to 55	12 to 47	74 to 90	0 to 15	20 to 24	24 to 44	12 to 20	9 to 18	6 to 16	10 to 21.3
Electrical Engineering	162 to 184	48 to 55	50 to 73.3	14 to 81	75 to 88.3	4 to 24	21 to 28	24 to 44	12 to 16	9 to 18	8 to 16	8 to 21.3
Chemical Engineering	162 to 195.5	46 to 73.5	42 to 58	4 to 18	84 to 97.3	4 to 18	20 to 24	37.3 to 50	12 to 16	8 to 18	12 to 18	8 to 12

Notes: Geology and mineralogy are included in the item of physical science.

In addition to the above groups miscellaneous non-engineering subjects are required in certain curricula in mechanical, electrical and chemical engineering included in the highest fifth.

The number of cases included under civil engineering is 83; mining engineering, 25; mechanical engineering, 76; electrical engineering 78; and chemical engineering, 56.

clusion of geology and mineralogy in the non-engineering requirements for mining engineers and the large amount of chemistry required of the chemical engineers, as reflected in the higher requirements in physical science in these two curricula. (See Fig. 4.) It may be noted that the electrical

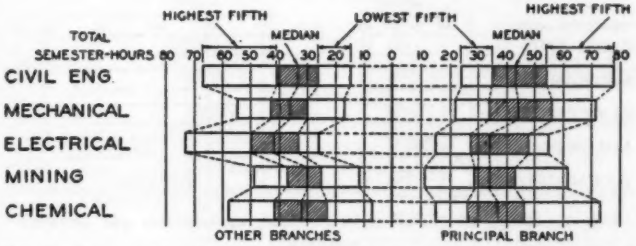


FIG. 2. Range of variation in prescribed requirements in the principal branch of engineering and in other engineering branches.

engineering curriculum tends to give the largest time allotment to other branches of engineering.

A comparison of Fig. 2 with Fig. 1 makes it apparent that the total requirements are relatively more closely standardized than the requirements in the engineering subjects proper. Fig. 3 makes it evident that there are wide variations of prac-

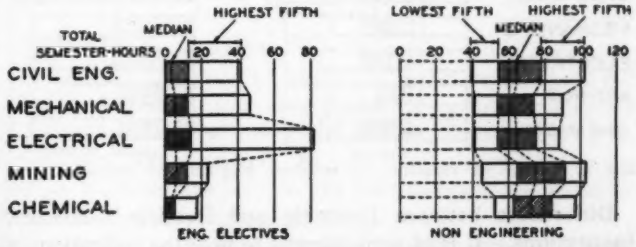


FIG. 3. Range of variation in engineering electives and in non-engineering requirements.

tice relating to engineering electives, with chemical engineering showing the least variability. Relatively limited provision for elective studies is a general characteristic of engineering curricula.

included in the highest fifth. Groups miscellaneous non-engineering subjects are required in certain curricula in mechanical, electrical and chemical engineering
The number of cases included under civil engineering is 83; mining engineering, 28; mechanical engineering, 76; electrical engineering 78; and chemical engineering, 65.

Fig. 4 shows the narrow range of standardization in mathematics. In the civil engineering curriculum the item of physical science is augmented by occasional requirements in astronomy and geology. As previously noted this item is aug-

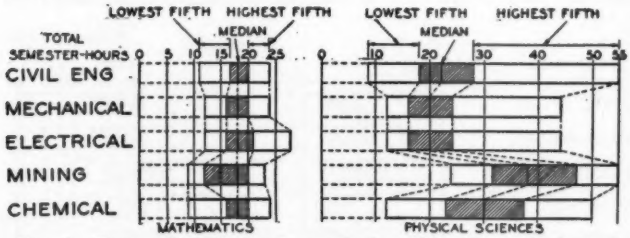


FIG. 4. Range of variation in required mathematics and physical sciences.

mented by large requirements in geology and mineralogy in the mining curriculum and by the more extended chemistry in chemical engineering. English and the social sciences indicate only moderate variability.

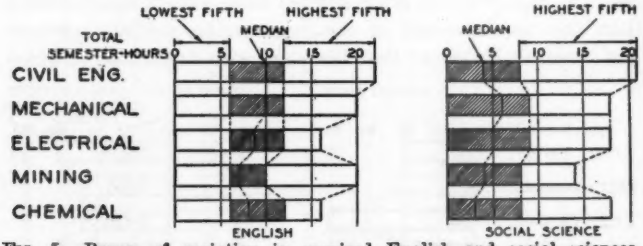


FIG. 5. Range of variation in required English and social sciences.

Differences between Privately and Publicly Controlled Institutions.—It is of some interest to note the indications of differences between the curricula of institutions under private control and those under public control. Differentials in median requirements have been taken from the detailed analyses of Part IV and assembled in Table II for this purpose. It is apparent that the privately controlled institutions have

somewhat larger total graduation requirements, especially in prescribed subjects. The public institutions, on the other hand, offer a wider latitude in electives. The private institutions set larger requirements in both non-engineering and engineering subjects, and in both the principal branch of engineering and the collateral branches.

TABLE II.

DIFFERENTIAL REQUIREMENTS IN PUBLICLY AND PRIVATELY CONTROLLED INSTITUTIONS.

(An excess requirement in privately controlled institutions in indicated by a + sign, and excess in the publicly controlled institutions by a — sign.)

	Curriculum.				
	Civil.	Mechanical.	Electrical.	Mining.	Chemical.
Total requirements	+3	+5.5	+5.5	−8	+10
Total prescribed	+9.5	+9.5	+8	−2	+17.2
Total elective	−1.5	−3	−3	−2	−8
Total engineering	+4.5	+3	0	−0.5	+9.5
Total principal branch	+3.5	+5	+3	−5	+7.5
Total other engineering	+5.4	+1	−2.5	+1.4	+6
Engineering electives	−4	−3	−3	−1	−3.4
Mathematics	−1	−1	−2	−4.7	−1
Physical science	+2	0	+0.5	−4	+1.5
Social science	+2	+1	+2	+4	+4
English	0	−1	+0.3	−1.5	0
Physical and military	−4.1	−4	−4.6	−5.5	−4.7
Mineralogy and geology				+4	
Foreign language	0	0	0	0	+6

The larger requirements in mathematics in the public institutions are obviously an offset to a lower requirement for entrance. Social sciences are plainly more largely stressed in private institutions, and physical and military training in those under public control. Foreign language appears in the median requirements only in the private institutions and in the chemical engineering curriculum.

Comparison with Agricultural Curricula.—In 1918 Dr. C. D. Jarvis of the United States Bureau of Education made a study of the agricultural curricula in the fifty land-grant colleges of the country. As the classifications of subject groups and other categories are very similar to those used in the present study of engineering fairly accurate comparisons may be

made between the two general types of curricula. For this purpose the median requirements in the mechanical engineering curricula of fifty-four state-controlled institutions have been selected. The two institutional lists, comprising fifty cases in agriculture and fifty-four in engineering, are substantially identical. Possibly the most serious criticism that can be directed against these comparisons is the fact that the studies by Dr. Jarvis are six years older than the data used in the engineering study. It seems probable, however, that the changes in the two types of curricula in that period have not been so great as seriously to invalidate the comparisons, with the possible exceptions of the requirements in mathematics and the social sciences.

TABLE III

COMPARISON OF CURRICULA IN MECHANICAL ENGINEERING AND IN AGRICULTURE

Subject Groups	Per Cent of Total Requirements	
	Mechanical Engineering	Agriculture
Mathematics	12.0	2.4
English	6.7	6.8
Physical science	13.4	24.4
Social science	3.4	4.7
Foreign language	0.0	2.7
Physical and military training	4.7	5.6
Non-technical electives	0 or 4.0	10.7
Technical electives	4.0	
Specific mechanical engineering or agriculture	28.1	31.3
Other engineering or agriculture	23.4	6.2[1] 5.1[2]

[1] Applied sciences.
[2] Agricultural engineering.

PART III. SUMMARY AND ANALYSIS OF ENTRANCE REQUIREMENTS

(See JOURNAL OF ENGINEERING EDUCATION, April, 1926, pp. 523 to 530 inc.)

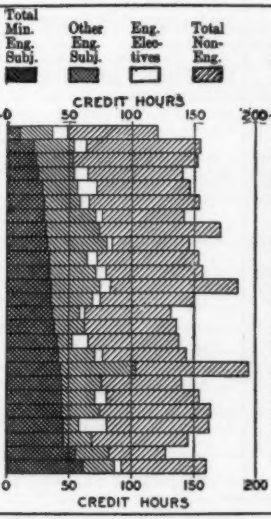
PART IV. SUMMARY AND ANALYSIS OF GRADUATION REQUIREMENTS

Part IV is divided into five sections, respectively devoted to the curricula in civil, mining, mechanical, electrical and chemical engineering. In each section there are presented: First, a graph showing the total semester-hour requirements of the individual institutions divided into separate items representing the principal engineering subject of the curriculum, other required engineering subjects, elective engineering subjects, and the total of non-engineering subjects, respectively, with the institutions arranged in the ascending order of their requirements in the principal engineering subject; second, a table in two parts which show the detailed requirements by subject groups in the publicly supported and the privately supported institutions respectively; and third, an analysis of the graduation requirements by subject groups with tables showing the distribution of the institutions within the range of requirements, together with maximum, minimum and median values.

A. Graduation Requirements in Civil Engineering

(See Journal of Engineering Education, April, 1926, pp. 522, and 532 to 549 inc.)

B. Graduation Requirements in Mining Engineering



Names of Institutions	Total Grad. Req.	Total Mining Eng. Subj.	Other Eng. Subj.	Eng. Elect.	Total Non Eng. Subj.
1 Leland Stanford University	121.3	10.7	27.3	13.3	70.0
2 University of Arizona	154	21	33	10	90
3 Virginia Polytechnic Institute	152	24	27.8	—	100.2
4 Yale University	140	25	28	12	75
5 Iowa State College	146	28.7	29.3	16	72
6 University of Alabama	158	30	30.5	7.5	85
7 Princeton University	141	30	42	6	63
8 Lehigh University	172	31	43	0	98
9 West Virginia University	146	32	49	3	62
10 University of Nevada	152	33	31	8	80
11 Notre Dame University	156	33	37	9	77
12 Missouri School of Mines	186	34	39.5	9	103.5
13 Lafayette College	150	34	33	6	77
14 University of Wyoming	131.2	36	23.2	2	70
15 University of Pittsburgh	137	37	25	0	75
16 Oregon Agricultural College	138	40	11.4	13.3	73.3
17 University of California	144	42	30	7	65
18 University of Kentucky	194	42.4	59.9	0	91.7
19 University of Illinois	140	43	32	0	65
20 University of North Dakota	155	43	27	10	75
21 Case School of Applied Science	166	43	31	0	92
22 Colorado School of Mines	165	44	13	24	84
23 University of Kansas	146+	44+	23	0	79
24 Harvard University	129	57	27	—	45
25 Ohio State University	160	62	26	6	66

Graph L. Total Semester-Hour Requirements in Principal Subject Groups, Mining Engineering Curricula.

TABLE VI.

MINING ENGINEERING, 1924–1925.

Graduation Requirements in 16 Publicly Controlled Institutions.

Names of Institutions.	Total Semester-Hours.	Total Prescribed Hours.	Total Elective Hours.	Mathematics.	English.	Physical Science.	Social Science.	Foreign Language.	Physical and Military Training.	Miscellaneous Subjects.	Non-Engineering Electives.	Mining and Metallurgy.	Other Engineering.	Engineering Electives.	Total Non-Engineering.	Total Engineering.	Geological Subjects.*
1. University of Alabama	153	145.5	7.5	20	4	51	6	0	4	0	—	30	30.5	7.5	85	68	20
2. University of Arizona	154	144	10	17	10	47	3	8	5	0	—	42	30	7	65	79	21
3. University of California	144	137	7	12	10	43	2	0	8	0	—	21	33	10	90	64	20
4. Colorado School of Mines	165	141	24	20	6	50	0	0	8	0	—	44	13	24[1]	84	81	18
5. University of Illinois	140	135	5	13	6	26	0	8	7	0	5	43	32	0	65	75	9
6. Iowa State College.*	146	130	16	19.3	8.7	35.3	(2)	0	4	0	4.7	28.7	29.3	16	72	74	8
7. University of Kansas	146+	138+	8	18	8	40	5	0	—	0	8	44+	23	0	79	67+	15
8. University of Kentucky	194	194	0	23	20	36.5	3	0	9.2	0	0	42.4	59.9	0	91.7	102.3	4
9. Missouri School of Mines	186	177	9	18	12	51.5	6	0	16	0	—	34	39.5	9	103.5	82.5	7
10. University of Nevada	152	144	8	16	6	46	2	0	10	0	—	33	31	8	80	72	18
11. University of North Dakota	155	145	10	18	10	37	4	0	6	0	—	43	27	10	75	80	16
12. Ohio State University.*	160	154	6	20	8	31.3	0	0	6.7	0	—	62	26	6	66	94	11.3
13. Oregon Agricultural College.*	138	124.7	13.3	13.3	6	38	6	0	10	0	—	40	11.4	13.3	73.3	64.7	13.3
14. Virginia Polytechnic Institute.*	152	136	16	20	10	44.7	4	0	5.1	.4	16	24	27.8	—	100.1	51.8	24
15. West Virginia University	146	143	3	16	7	25	10	0	4	0	0	32	49	3	62	84	(5)
16. University of Wyoming.*	131.2	129.2	2	18	6	38	0	0	8	0	0	36	23.2	2	70	61.2	14.6

Graduation Requirements in 9 Privately Controlled Institutions.

1. Leland Stanford Junior University†	121.3	108	13.3	13.3	4	32.7	14	6	—	—	—	10.7	27.3	13.3	70	51.3	15.3
2. Yale University	140	128	12	12	12	39	12	0	0	0	(6)	25	28	12	75	65	19
3. University of Notre Dame	156	147	9	18	10	35	0	0	0	14	—	33	37	9	77	79	24
4. Harvard University	129	126	3	12	6	24	0	0	0	0	3	57	27	—	45	84	18
5. Princeton University	141	135	6	9	8	24	14	6	2	0	0	30	42	6	63	78	(27)
6. Case School of Applied Science	166	166	0	18	12	40	4	11	7	0	0	43	31	0	92	74	19
7. Lehigh University	172	172	0	15	6	55	6	6	6	4	0	31	43	0	98	74	(24)
8. Lafayette College	150	144	6	17	6	34	8	0	4	8	—	34	33	6	7	73	(12)
9. University of Pittsburgh	137	137	0	12	6	44	7	0	6	0	—	37	25	0	75	62	(16)

* Included under physical science.
† Reduced from term hours to semester hours.
[1] Including non-technical.

Analysis of Graduation Requirements in Mining Engineering

Total Graduation Requirements.—There are twenty different cases of total graduation requirements in mining engineering in the list of twenty-five colleges included in this section of the study. These requirements vary from 121.3 to 194 semester-hour credits.

In the tables following are given the modal tendencies, the minimum, maximum, and median figures for total graduation requirements in mining engineering.

Total Graduation Requirements, Mining Engineering Curricula.

Number of Cases.	In Public Institutions.	In Private Institutions.	Number of Graduation Requirements in Semester-hour Credits.
2	0	2	121.3 and 129
3	2	1	131 to 139
8	6	2	140 to 146
5	4	1	152 to 156
3	2	1	160 to 166
3	2	1	172 to 194

Minimum, Maximum, and Median; Total Graduation Requirements.

Requirements.	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum.....	121.3	131.2	121.3
Maximum.....	194	194	172
Median.....	146	Bet. 146 and 152	141

Total Prescribed Credits.—The following tables show the principal frequencies or modal tendencies in total prescribed semester-hour credits in mining engineering including minimum, maximum, and median figures.

Total Prescribed Credits, Mining Engineering Curricula.

Number of Cases.	In Public Institutions.	In Private Institutions.	Number of Prescribed Semester-hour Credits.
4	2	2	124.7 to 129.2
8	6	2	130 to 137
8	6	2	141 to 147
5	3	2	151 to 194

† Reduced from term hours to semester hours.

MINIMUM, MAXIMUM, AND MEDIAN; TOTAL PRESCRIBED CREDITS.

Requirements.	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum.....	108	124.7	108
Maximum.....	194	194	172
Median.....	141	Bet. 137 and 141	137

Total Elective Credits.—The following tables show the principal frequencies or modal tendencies in total elective semester-hour credits in mining engineering also minimum, maximum, and median requirements.

TOTAL ELECTIVE CREDITS, MINING ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Number of Elective Semester-hour Credits.
4	1	3	0
13	9	4	2 to 9
7	5	2	10 to 13.3
1	1	0	24

MINIMUM, MAXIMUM, AND MEDIAN; TOTAL ELECTIVE CREDITS.

Requirements.	In All Institutions (25).	In Public Institutions (16).	In Private Institutions (9).
Minimum.....	0 or 2	0 or 2	0 or 3
Maximum.....	24	24	13.3
Median.....	8	8	6

These tables show that 16 per cent of all the institutions—6.2 per cent of the public and 33 per cent of the private institutions on our list—do not require elective work.

Requirements in Mathematics.—The following tables show the principal frequencies or modal tendencies for graduation requirements in mathematics, also the minimum, maximum, and median figures.

REQUIREMENTS IN MATHEMATICS, MINING ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits Prescribed in Mathematics.
1	0	1	9
5	1	3	12
6	4	2	18
4	4	0	20

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN MATHEMATICS.

Requirements.	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum	9	12	9
Maximum	23	23	18
Median	18	18	13.3

Requirements in English.—The following tables show the principal frequencies or modal tendencies for graduation requirements in English, also the minimum, maximum, and median figures.

REQUIREMENTS IN ENGLISH, MINING ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits Prescribed in English.
1	1	0	0
2	1	1	4
9	5	4	6
1	1	0	7
3	2	1	8
1	1	0	8.7
4	3	1	10
3	1	2	12
1	1	0	20

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN ENGLISH.

Requirements	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum	0 or 4	0 or 4	4
Maximum	20	20	12
Median	7	Bet. 7 and 8	6

Requirements in Physical Science.—The following tables show the principal frequencies or modal tendencies for graduation requirements in physical science, also the minimum, maximum, and median figures.

REQUIREMENTS IN PHYSICAL SCIENCE, MINING ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hours Prescribed in Physical Science.
4	2	2	24 to 26
10	6	4	31.3 to 39
7	5	2	40 to 47
4	3	1	50 to 55

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN PHYSICAL SCIENCE.

Requirements.	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum.....	24	25	24
Maximum.....	55	51.5	55
Median.....	38	Bet. 38 and 40	35

Requirements in Geology and Mineralogy.—Inasmuch as the physical science requirements for mining engineering include a considerable amount of geology and mineralogy the following tables have been prepared showing the tendencies with respect to requirements in these subjects.

REQUIREMENTS IN GEOLOGY AND MINERALOGY, MINING ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hours Prescribed in Geology and Mineralogy.
2	2	0	4 and 5
3	3	0	7 to 9
13	7	6	11.3 to 19
7	4	3	20 to 27

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN GEOLOGY AND MINERALOGY.

Requirements.	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum.....	4	4	12
Maximum.....	27	24	27
Median.....	16	15	19

Comparing the median requirements of physical science with those of geology, etc., we find that geological subjects comprise 42 per cent of the science subjects required in all the institutions, 40 per cent of the science subjects in the public institutions and 54 per cent of the science subjects in the private institutions.

Requirements in Social Science.—The following tables show the principal frequencies or modal tendencies for graduation requirements in social science, also minimum, maximum, and median figures.

REQUIREMENTS IN SOCIAL SCIENCE, MINING ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hours Prescribed in Social Science.
6	4	2	0
8	7	1	2 to 4
7	4	3	5 to 8
4	1	3	10 to 14

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN SOCIAL SCIENCE.

Requirements.	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum.....	0 or 2	0 or 2	0 or 4
Maximum.....	14	10	14
Median.....	4	3	7

The foregoing tables show that 24 per cent of all of the institutions—25 per cent of the public and 22 per cent of the private institutions—do not prescribe social science.

Requirements in Foreign Language.—The following tables show the principal frequencies or modal tendencies for graduation requirements in foreign language, also the minimum, maximum, and median figures.

REQUIREMENTS IN FOREIGN LANGUAGE, MINING ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits Prescribed in Foreign Language.
19	14	5	0
3	0	3	6
2	2	0	8
1	0	1	11

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN FOREIGN LANGUAGE.

Requirements.	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum.....	0 or 6	0 or 8	0 or 6
Maximum.....	11	8	11
Median.....	0	0	0

The tables show that 76 per cent of all the institutions—87 per cent of the public and 55 per cent of the private institutions—do not prescribe foreign language for graduation in mining engineering.

Requirements in Physical and Military Training, and Hygiene.—The following tables show the principal frequencies and modal tendencies in physical and military training, including hygiene, also the minimum, maximum, and median figures.

REQUIREMENTS IN PHYSICAL AND MILITARY TRAINING, INCLUDING HYGIENE; MINING ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits Prescribed in Physical and Military Training.
5	1	4	0
1	0	1	2
4	3	1	4
12	9	3	5 to 9.2
2	2	0	10
1	1	0	16

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN PHYSICAL AND MILITARY TRAINING.

Requirements.	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum.....	0 or 2	0 or 4	0 or 2
Maximum.....	16	16	7
Median.....	6	Bet. 7 and 8	2

The foregoing tables show that 20 per cent of the institutions—6 per cent of the public and 44 per cent of the private institutions—do not prescribe physical and military training, etc.

Requirements in Prescribed Miscellaneous Subjects.—Only one of the public institutions and three of the private institutions prescribe work in specific subjects other than those indicated in the preceding paragraphs. These subjects include orientation courses, religion or Bible, and chapel.

Non-Engineering Electives.—Eleven of the public institutions and seven of the private institutions do not specify non-engineering electives as a part of the graduation requirements in mining engineering. In the list of public institutions the specific amount of credits allowed are as follows: 4.7, 5, 8 and 16; in the private, 3 and 6 semester-hours.

Total Non-Engineering Subjects.—The following tables show the principal frequencies or modal tendencies in total non-engineering subjects, also minimum, maximum, and median figures.

TOTAL REQUIREMENTS IN NON-ENGINEERING SUBJECTS, MINING ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits in Non-engineering Subjects.
1	0	1	45
1	0	1	51.3
6	5	1	62 to 66
8	4	4	70 to 77
3	3	0	80 to 85
4	2	2	90 to 98
2	2	0	100.2 and 103.5

MINIMUM, MAXIMUM, AND MEDIAN; TOTAL REQUIREMENTS IN NON-ENGINEERING SUBJECTS.

Requirements.	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum.....	45	62	45
Maximum.....	103.5	103.5	98
Median.....	75	Bet. 73.3 and 74	75

Total Engineering Subjects.—The following tables show the principal frequencies or modal tendencies in total engineering subjects, also minimum, maximum, and median figures.

TOTAL REQUIREMENTS IN ENGINEERING SUBJECTS, MINING ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits in Engineering Subjects.
1	1	0	51.8
7	5	2	61.2 to 68
10	4	6	70 to 79
5	4	1	80 to 84
1	1	0	94
1	1	0	102.3

MINIMUM, MAXIMUM, AND MEDIAN; TOTAL REQUIREMENTS IN ENGINEERING SUBJECTS.

Requirements.	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum.....	51.8	51.8	62
Maximum.....	102.3	102.3	84
Median.....	74	Bet. 74 and 75	74

Specific Subjects in Mining Engineering.—The tables following show the principal frequencies or modal tendencies in specific subjects in mining engineering, also minimum, maximum, and median figures. The specific subjects in mining engineering include courses in mine surveying, principles of mining, metallurgy, treatment of ores, mining methods, mine ventilation, metal mining, coal mining, mine accounting and

other technical subjects in mining and metallurgy. In selecting the curricula for analysis it has been found desirable to follow the general curriculum in mining in cases where no options are offered, but where options are required the metal mining option has been selected.

SPECIFIC SUBJECTS IN MINING ENGINEERING, MINING ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits in Specific Mining Subjects.
1	0	1	10.7
4	3	1	21 to 28.7
10	5	5	30 to 37
8	7	1	40 to 44
1	1	0	62

MINIMUM, MAXIMUM, AND MEDIAN; SPECIFIC SUBJECTS IN MINING ENGINEERING.

Requirements.	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum.....	10.7	21	10.7
Maximum.....	62	62	57
Median.....	34	Bet. 36 and 40	33

Requirements in Engineering Subjects other than Mining Engineering.—The following tables show the principal frequencies or modal tendencies in other engineering subjects, also minimum, maximum, and median figures.

OTHER ENGINEERING SUBJECTS, MINING ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits in Other Engineering Subjects.
2	2	0	11.4 to 13
10	6	4	23 to 29.3
9	6	3	30 to 39.5
3	1	2	42 to 49
1	1	0	59.9

MINIMUM, MAXIMUM, AND MEDIAN; OTHER ENGINEERING SUBJECTS.

Requirements.	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum.....	11.4	11.4	25
Maximum.....	59.9	59.9	43
Median.....	30	Bet. 29.3 and 30	31

Requirements in Engineering Electives.—The following tables show the principal frequencies or modal tendencies in engineering electives of mining engineering curricula, also the minimum, maximum, and median figures.

ENGINEERING ELECTIVES, MINING ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits in Engineering Electives.
8	4	4	0
10	7	3	2 to 9
7	4	3	10 to 16
1	1	0	24

MINIMUM, MAXIMUM, AND MEDIAN; ENGINEERING ELECTIVES.

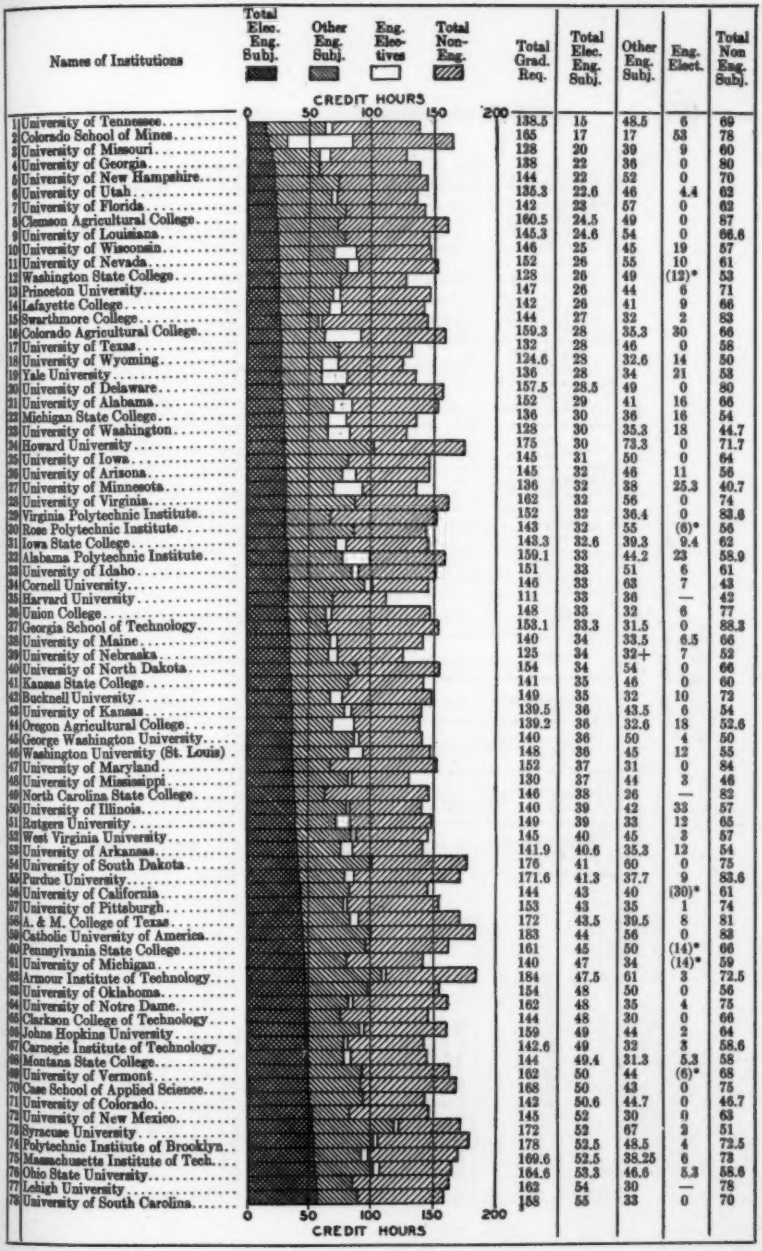
Requirements.	For All Institutions (25).	For Public Institutions (16).	For Private Institutions (9).
Minimum.....	0 or 2	0 or 2	0 or 6
Maximum.....	24	24	13.3
Median.....	6	7	6

These tables show that 32 per cent of all the institutions—25 per cent of the public and 44 per cent of those which are private—do not require engineering electives.

C. GRADUATION REQUIREMENTS IN MECHANICAL ENGINEERING

(See JOURNAL OF ENGINEERING EDUCATION, May, 1926, pp. 584 to 601 inc.)

D. Graduation Requirements in Electrical Engineering



	Names of Institutions	Total Grad. Req.	Total Elec. Eng. Subj.	Other Eng. Subj.	Eng. Elect.	Total Non Eng. Subj.
1	University of Tennessee	138.5	15	48.5	6	69
2	Colorado School of Mines	165	17	17	53	78
3	University of Missouri	128	20	39	9	60
4	University of Georgia	128	22	36	0	80
5	University of New Hampshire	144	22	52	0	70
6	University of Utah	135.3	22.6	46	4.4	62
7	University of Florida	142	22	57	0	62
8	Clemson Agricultural College	160.5	24.5	49	0	87
9	University of Louisiana	145.3	24.6	54	0	66.6
10	University of Wisconsin	146	25	45	19	57
11	University of Nevada	152	26	55	10	61
12	Washington State College	128	26	49	(12)*	53
13	Princeton University	147	26	44	9	71
14	Lafayette College	142	26	41	9	66
15	Swarthmore College	144	27	32	2	83
16	Colorado Agricultural College	159.3	28	35.3	30	66
17	University of Texas	132	28	46	0	58
18	University of Wyoming	124.6	28	32.6	14	50
19	Yale University	136	28	34	21	53
20	University of Delaware	157.5	28.5	49	0	80
21	University of Alabama	152	29	41	16	66
22	Michigan State College	136	30	36	16	54
23	University of Washington	128	30	35.3	18	44.7
24	Howard University	175	30	73.3	0	71.7
25	University of Iowa	145	31	50	0	64
26	University of Arizona	145	32	46	11	56
27	University of Minnesota	136	32	38	25.3	40.7
28	University of Virginia	162	32	56	0	74
29	Virginia Polytechnic Institute	152	32	36.4	0	82.6
30	Rose Polytechnic Institute	143	32	55	(6)*	56
31	Iowa State College	143.3	32.6	39.3	9.4	62
32	Alabama Polytechnic Institute	159.1	33	44.2	23	58.9
33	University of Idaho	151	33	51	6	61
34	Cornell University	146	33	63	7	43
35	Harvard University	111	33	36	—	42
36	Union College	148	33	32	6	77
37	Georgia School of Technology	153.1	33.3	31.5	0	88.3
38	University of Maine	140	34	33.5	6.5	66
39	University of Nebraska	125	34	32+	7	52
40	University of North Dakota	154	34	54	0	66
41	Kansas State College	141	35	46	0	60
42	Bucknell University	149	35	32	10	72
43	University of Kansas	139.5	36	43.5	6	54
44	Oregon Agricultural College	139.2	36	32.6	18	52.6
45	George Washington University	140	36	50	4	50
46	Washington University (St. Louis)	148	36	45	12	55
47	University of Maryland	152	37	31	0	84
48	University of Mississippi	130	37	44	3	46
49	North Carolina State College	146	38	26	—	82
50	University of Illinois	140	39	42	33	57
51	Rutgers University	149	39	33	12	65
52	West Virginia University	145	40	45	3	57
53	University of Arkansas	141.9	40.6	35.3	12	54
54	University of South Dakota	176	41	60	0	75
55	Purdue University	171.6	41.3	37.7	9	83.6
56	University of California	144	43	40	(30)*	61
57	University of Pittsburgh	153	43	35	1	74
58	A. & M. College of Texas	172	43.5	39.5	8	81
59	Catholic University of America	183	44	56	0	83
60	Pennsylvania State College	161	45	50	(14)*	66
61	University of Michigan	140	47	34	(14)*	59
62	Armour Institute of Technology	184	47.5	61	3	72.5
63	University of Oklahoma	154	48	50	0	56
64	University of Notre Dame	162	48	35	4	75
65	Clarkson College of Technology	144	48	30	0	66
66	Johns Hopkins University	159	49	44	2	64
67	Carnegie Institute of Technology	142.6	49	32	3	58.6
68	Montana State College	144	49.4	31.3	5.3	58
69	University of Vermont	162	50	44	(6)*	68
70	Case School of Applied Science	168	50	43	0	75
71	University of Colorado	143	50.6	44.7	0	46.7
72	University of New Mexico	145	52	30	0	63
73	Syracuse University	172	52	67	2	51
74	Polytechnic Institute of Brooklyn	178	52.5	48.5	4	72.5
75	Massachusetts Institute of Tech.	169.6	52.5	38.25	6	72
76	Ohio State University	164.6	53.3	46.6	5.3	58.6
77	Lehigh University	162	54	30	—	78
78	University of South Carolina	188	55	33	0	70

Graph N. Total Semester-Hour Requirements in Principal Subject Groups, Electrical Engineering Curricula.

*Options—not included in Total Graduation Requirements.

TABLE VIII.

Electrical Engineering, 1924–1925.

Graduation Requirements in 55 Publicly Controlled Institutions.

Names of Institutions.	Total Semester Hours.	Total Prescribed Hours.	Total Elective Hours.	Mathematics.	English.	Physical Science.	Social Science.	Foreign Language.	Physical and Military Training.	Miscellaneous Subjects.	Non-Engineering Electives.	Electrical Engineering.	Other Engineering.	Engineering Electives.	Total Non-Engineering.	Total Engineering.
1. Alabama Polytechnic Institute	159.1	136.1	23	20	12	15.3	5	0	6.6	0	0	33	44.2	23	58.9	100.2
2. University of Alabama	152	136	16	25	4	22	10	0	4	1	0	29	41	16	66	86
3. University of Arizona	145	134	11	17	10	16	0	8	4	1	0	32	46	11	56	89
4. University of Arkansas.*	141.9	129.9	12	22	6	18	6	0	4	0	(12)	40.6	35.3	12	54	87.9
5. University of California	144[1]	120	24	12	—	22	0	0	8	0	15	43	40	(30)	61	83
6. University of Colorado.*	142	142	0	18	8.6	18	0	0	2	0	0	50.6	44.7	0	46.7	95.3
7. Colorado Agricultural College	159.3	129.3	30	24	6	20	0	0	16	0	—	28	35.3	30	66	93.3
8. Colorado School of Mines	165	112	53	20	6	44	0	0	8	0	—	17	17	53	78	87
9. University of Delaware	157.5	157.5	0	24	12	19	7	6	12	0	0	28.5	49	0	80	77.5
10. University of Florida	142	142	0	16	8	26	3	0	9	0	0	23	57	0	62	80
11. University of Georgia	138	138	0	24	6	38	0	12	0	0	0	22	36	0	80	58
12. Georgia School of Technology	153.1	153.1	0	23.7	15	22	9	12	6.6	0	0	33.3	31.5	0	88.3	64.8
13. University of Idaho	151	145	6	21	10	22	0	0	8	0	—	33	51	6	61	90
14. University of Illinois	140	129	11	15	6	12	0	8	7	0	8	39	42	3	56	84
15. Purdue University	171.6	162.6	9	20	12	14.3	6	10	21.3	—	—	41.3	37.7	9	83.6	88
16. State University of Iowa	145	145	0	20	12	19	5	0	8	0	0	31	50	80	64	81
17. Iowa State College.*	143.3	133.9	9.4	19.3	8.7	24	6+	0	4	0	—	32.6	39.3	9.4	62	81.3
18. University of Kansas	139.5	133.5	6	20	8	23	3	0	—	0	—	36	43.5	6	54	85.5
19. Kansas State Agricultural College	141	141	0	18	10	18	8	0	6	0	0	35	46	0	60	81
20. Louisiana State University.*	145.3	145.3	0	20.6	12	24	4	0	6	0	0	24.6	54	0	66.6	78.6
21. University of Maine	140	133.5	6.5	20	12	21	13	0	—	0	—	34	33.5	6.5	66	74
22. University of Maryland	152	152	(6)	20	14	22	6+	14	8	0	(6)	37	31	0	84	68
23. University of Michigan	140	140	(14)	18	6	19	—	16	0	—	—	47	34	(14)	59	81
24. Michigan State College.*	136	114	22	16	8	16	—	—	8	—	6	30	36	16	54	82
25. University of Minnesota	136	111.7	25.3	16.7	6	18	—	—	—	—	0	32	38	25.3	40.7	95.3
26. University of Mississippi	130	127	3	18	6	16	0	6	0	0	—	37	44	3	46	84
27. University of Missouri	128	119	9	20	12	15	5	0	8	0	—	20	39	9	60	68
28. Montana State College.*	144	138.7	5.3	18	10	18	4	0	8	—	—	49.4	31.3	5.3	58	86

Name of Institution.	Total Semester Hours.	Total Prescribed Hours.	Total Elective Hours.	Mathematics.	English.	Physical Science.	Social Science.	Foreign Language.	Physical and Military Training.	Miscellaneous Subjects.	Non-Engineering Electives.	Electrical Engineering.	Other Engineering.	Engineering Electives.	Total Non-Engineering.	Total Engineering.
29. University of Nebraska	125	118	7	20	4	16	6	0	4	2	| |	34	32+	7	52	73
30. University of Nevada	152	142	10	16	6	27	2	0	10	0	12	26	55	10	61	91
31. University of New Hampshire	144	132	12	18	10	22	|	0	8	0	|	22	52	0	70	74
32. Rutgers University	140	137	12	20	12	14	4	0	9	0	|	39	33	12	65	84
33. Cornell University	130	123	7	14	4	21	4	0	|	2	12	33	63	7	43	103
34. University of New Mexico	146	133	12	18	9	22	|	|	8	2	24	52	30	0	63	83
35. North Carolina State College.*	146	122	24	20	12	18	|	|	6	0	0	38	26	82	82	64
36. University of North Dakota	154	154	0	18	14	22	6	0	6	0	0	34	54	0	66	88
37. Ohio State University.*	164.6	158.6	6	20	6	22	4	0	6.6	0	0	53.3	46.6	5.3 to 6	58.6	106
38. University of Oklahoma	154	154	0	19	8	18	7	0	4	0	0	48	50	0	56	98
39. Oregon Agricultural College.*	139.2	121.2	18	16	8	12	6	0	10	6	0	36	32.6	18	52.6	88.6
40. Pennsylvania State College.*	161	145	16	16	10	14	9	0	9	0	0	45	50	(14)[3]	66	95
41. University of South Carolina	158	158	0	18	12	25	9	0	0	0	0	55	33	0	70	88
42. Clemson Agricultural College	160.5	160.5	0	21	16	20	10	0	20	0	0	24.5	49	0	87	73.5
43. University of South Dakota	176	176	0	21	16	33	3	0	12	0	0	41	60	0	75	101
44. University of Tennessee	138.5	132.5	6	18	12	19	6	0	20	0	0	15	48.5	0	69	69.5
45. University of Texas.*	132	132	0	18	12	28	6	0	0	0	0	28	46	0	68	74
46. Agricultural and Mechanical College of Texas	172	152	20	22	16	17	6	0	8	0	12	43.5	39.5	8	81	91
47. University of Utah.*	135.3	130.6	4.7	20	6	22	12	0	2	0	0	22.6	46	4.4	62	73.3
48. University of Vermont	162	162	(6)	24	8	20	4	12	12	0	0	50	44	(6)[3]	68	94
49. University of Virginia.*	162	162	0	20	12	24	18	0	0	4	0	32	56	0	74	88
50. Virginia Polytechnic Institute.*	152	152	0	22	12	24	4	0	21+	0	0	32	36.4	0	83.6	68.4
51. University of Washington.*	128	110	18	14	8	22	4	0	6.7	0	|	30	35.3	18	44.7	53.3
52. State College of Washington	128	116	12	16	8	14	8	0	7	0	|	26	49	(12)	53	75
53. West Virginia University	145	142	3	16	7	20	4	0	|	0	0	40	45	3	57	88
54. University of Wisconsin	146	118	28	18	6	20	4	0	8	0	9+	25	45	19	57+	89
55. University of Wyoming.*	124.6	110.6	14	18	6	18	0	0	|	0	|	29	32.6	14	50	74.6

* Figures reduced to semester-hours from a term or quarter basis.
[1] 3 hours summer in addition.
[2] On an average 14 elective credits are taken in major departments.
[3] Included in total.
[4] Includes 5 hours summer work.

TABLE VIII.

ELECTRICAL ENGINEERING, 1924–1925—*Continued.*

Graduation Requirements in 23 Privately Controlled Institutions.

Names of Institutions.	Total Semester Hours.	Total Prescribed Hours.	Total Elective Hours.	Mathematics.	English.	Physical Science.	Social Science.	Foreign Language.	Physical and Military Training.	Miscellaneous Subjects.	Non-Engineering Electives.	Electrical Engineering.	Other Engineering.	Engineering Electives.	Total Non-Engineering.	Total Engineering.
1. Yale University	136	115	21	12	12	17	12	0	0	0	(21)	28	34	21	53	83
2. George Washington University	140	136	4	12	6	20	6	6	0	0	—	36	50	4	50	90
3. Catholic University of America	183	183	0	22	12	28	0	6	0	15	0	44	56	0	83	100
4. Howard University.*	175	175	0	20	10	16.7	10	0	15	0	0	30	73.3	0	71.7	103.3
5. Armour Institute of Technology	184	181	3	18	10	28.5	12	0	—	4	0	47.5	61	3	72.5	111.5
6. University of Notre Dame	162	158	4	24	10	21	3	0	—	14	0	48	35	4	75	87
7. Rose Polytechnic Institute	143	124	19	17	8	15	2	10	4	0	(13)	32	55	(6)	56	87
8. Johns Hopkins University	159	153	6	18	6	22	6	8[1]	—	0	4[2]	49	44	2[2]	64	95
9. Harvard University	111	105	6	12	6	12	6	0	0	0	6	33	36	—	42	69
10. Massachusetts Institute of Technology	169.7	163.7	6	14	15	26	6	0	12	0	—	52.5	38.2	6	73	96.7
11. Washington University (St. Louis)	148	136	12	17	8	20	6	0	4	0	—	36	45	12	55	93
12. Princeton University	147	141	6	12	8	23	14	12	2	0	—	26	44	6	71	76
13. Polytechnic Institute of Brooklyn	178	174	4	17	13	24.5	14	0	4	0	—	52	48.5	4	72.5	105.5
14. Clarkson College of Technology.*	144	144	0	18	6	24	14	0	4	0	0	48.5	30	0	66	78
15. Union College	148	142	6	28	14	16	7	10	0	2	—	33	32	6	77	71
16. Syracuse University	172	170	2	22	8	18	3	0	0	0	0	52	67	2	51	121
17. Case School of Applied Science	168	168	0	21	12	21	2	12	7	0	0	50	43	0	75	93
18. Lehigh University	162	162	—	16	9	23	6	6	14	4	—	54	30	—	78	84
19. Lafayette College	142	133	9	20	9	19	6	0	4	8	—	26	41	9	66	76
20. Bucknell University	149	139	10	17	6	32	0	12	0	2	—	35	32	10	72	77
21. Swarthmore College	144	142	2	21	10	24	16	12	—	—	—	27	32	2	83	61
22. Carnegie Institute of Technology.†	142.6	139.6	3	18	6	18	12	0	4.6	0	—	49	32	3	58.6	84
23. University of Pittsburgh	153	148	5	14	14	26	5	0	4	7	4	43	35	1	74	79

* Figures reduced to semester hours from a term or quarter basis.
† Reduced from Carnegie Institute units.
[1] Or Military Training.
[2] Includes 2½ hours summer survey.
[3] Senior elective not designated technical.

Analysis of Graduation Requirements in Electrical Engineering

Total Graduation Requirements.—In the list of seventy-eight institutions included in this study there are forty-seven different cases of total graduation requirements. These totals vary from 111 to 184 semester-hour credits.

In the following tables are given in semester-hour credits the principal frequencies or modal tendencies of the total graduation requirements in electrical engineering; and likewise the minimum, maximum and median figures.

Total Graduation Requirements, Electrical Engineering Curricula.

Number of Cases.	In Public Institutions.	In Private Institutions.	No. of Graduation Requirements in Semester-hour Credits.
1	0	1	111
5	5	0	124 to 129
10	9	1	130 to 139.5
31	21	10	140 to 149
13	11	2	150 to 159.3
10	6	4	160 to 169.6
6	3	3	170 to 179
2	0	2	183 and 184

Minimum, Maximum, and Median; Total Graduation Requirements.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	111	124.6	111
Maximum.....	184	176	184
Median.....	145	145	149

Total Prescribed Credits.—The following tables show the principal frequencies or modal tendencies in total prescribed semester-hour credits in electrical engineering curricula; also, the minimum, maximum, and median figures.

TOTAL PRESCRIBED CREDITS, ELECTRICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	No. of Prescribed Semester-hour Credits.
3	2	1	105 to 110.6
8	7	1	111.7 to 119
8	7	1	120 to 129.9
20	15	5	130.6 to 139.6
15	10	5	140 to 148
11	9	2	152 to 158.6
7	4	3	170 to 175
2	0	2	181 and 183

MINIMUM, MAXIMUM, AND MEDIAN; TOTAL PRESCRIBED CREDITS.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	105	110	105
Maximum.....	183	176	183
Median.....	139	136	144

Total Elective Credits.—The following tables show the principal frequencies or modal tendencies in the total elective semester-hour credits in electrical engineering curricula; there are also included the minimum, maximum, and median figures.

TOTAL ELECTIVE CREDITS, ELECTRICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	No. of Elective Sem.-hour Credits.
21	16	5	0
10	3	7	2 to 4.7
20	13	7	5 to 9.4
17	14	3	10 to 19
8	7	1	20 to 28
1	1	0	30
1	1	0	53

MINIMUM, MAXIMUM, AND MEDIAN; TOTAL ELECTIVE CREDITS.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	0 or 2	0 or 3	0 or 2
Maximum.....	53	53	21
Median.....	6	7	4

These tables show that 27 per cent of the schools—approximately 30 per cent of the public, and 22 per cent of the private institutions—offer no electives in the electrical engineering curriculum.

Requirements in Mathematics.—The tables following show the principal frequencies or modal tendencies for graduation requirements in mathematics.

REQUIREMENTS IN MATHEMATICS, ELECTRICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Sem.-hour Credits Prescribed in Mathematics.
6	2	4	12
8	7	1	16
16	12	4	18
16	14	2	20

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN MATHEMATICS.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	12	12	12
Maximum.....	28	25	28
Median.....	18	19	17

Requirements in English.—The tables following show the principal frequencies or modal tendencies for graduation requirements in English, including also the minimum, maximum, and median figures.

REQUIREMENTS IN ENGLISH, ELECTRICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Sem.-hour Credits Prescribed in English.
1	1	0	0[1]
20	14	6	6
11	7	4	8
10	6	4	10
16	13	3	12

[1] The University of California requires an examination in English.

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN ENGLISH.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	0 or 2	0 or 2	0 or 6
Maximum.....	16	16	15
Median.....	8.7	8.7	9

Requirements in Physical Science.—The next tables show the principal frequencies or modal tendencies for graduation requirements in physical science, including also the minimum, maximum, and median figures.

REQUIREMENTS IN PHYSICAL SCIENCE, ELECTRICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Sem.-hour Credits Prescribed in Phys. Science.
5	4	1	16
10	8	2	18
7	5	2	20
14	13	1	22
7	4	3	24

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN PHYSICAL SCIENCE, ELECTRICAL ENGINEERING CURRICULA.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	12	12	12
Maximum.....	44	44	32
Median.....	20	20	Bet. 20 and 21

Requirements in Social Science.—The following tables show the principal frequencies or modal tendencies for graduation requirements in social science, including, also, minimum, maximum, and median figures.

REQUIREMENTS IN SOCIAL SCIENCE, ELECTRICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Sem.-hour Credits Prescribed in Social Science.
20	18	2	0
8	8	0	4
16	9	7	6
12	10	2	7 to 10
10	3	7	12 to 18

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN SOCIAL SCIENCE.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	0 or 2	0 or 2	0 or 2
Maximum.....	18	18	16
Median.....	5	4	6

These tables show that nearly 26 per cent of all the institutions—nearly 33 per cent of the public, and nearly 9 per cent of the private institutions of our list—do not prescribe social science.

Requirements in Foreign Language.—In the following tables are given the principal frequencies or modal tendencies for graduation requirements in foreign language including also the minimum, maximum, and median figures.

REQUIREMENTS IN FOREIGN LANGUAGE, ELECTRICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Sem.-hour Credits Prescribed in Foreign Language.
55	42	13	0
1	1	0	4
7	4	3	6
3	1	2	10
6	2	4	12
1	1	0	14
1	1	0	16

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN FOREIGN LANGUAGE.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	0 or 4	0 or 4	0 or 6
Maximum.....	16	16	16
Median.....	0	0	0

These tables show that more than 70 per cent of all the institutions—76 per cent of the public and 26 per cent of the private institutions—do not prescribe foreign language for graduation in electrical engineering.

Requirements in Physical and Military Training, and Hygiene.—The following tables show the principal frequencies or modal tendencies for graduation requirements in physical and military training, including hygiene.

REQUIREMENTS IN PHYSICAL AND MILITARY TRAINING, INCLUDING HYGIENE, ELECTRICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Sem.-hour Credits Prescribed in Physical and Military Training.
24	13	11	0
3	2	1	2
12	6	6	4
11	9	2	4.6 to 7
12	12	0	8
5	5	0	9 to 10
11	8	3	12 to 21.3

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN PHYSICAL AND MILITARY TRAINING.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	0 or 2	0 or 2	0 or 2
Maximum.....	21.3	21.3	15
Median.....	4	6.6	2

The foregoing tables show that over 30 per cent of all of the institutions—nearly 24 per cent of the public, and nearly

one-half of the private institutions—do not prescribe physical and military training for graduation in electrical engineering.

Requirements in Prescribed Miscellaneous Subjects.—As in mechanical engineering, fourteen of our list prescribe certain subjects for graduation in electrical engineering in addition to those already mentioned. These subjects as mentioned heretofore include Bible, religion, psychology, philosophy and orientation courses.

Non-Engineering Electives.—Fifteen institutions of the seventy-eight specify non-engineering electives as a part of graduation requirements in electrical engineering. The more important frequencies are given in the following table:

NON-ENGINEERING ELECTIVES, ELECTRICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Sem.-hour Credits Prescribed in Non-engineering Electives.
63	45	18	0
3	2	1	6
4	4	0	12
8	4	4	Other credits

This table shows the relative insignificance of the non-engineering electives in the curricula in electrical engineering. (This does not include specific options.)

Total Non-Engineering Subjects.—The following table indicates the principal frequencies or modal tendencies in total non-engineering subjects, including the minimum, maximum, and median figures.

TOTAL REQUIREMENTS IN NON-ENGINEERING SUBJECTS, ELECTRICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Sem.-hour Credits Prescribed in Non-Engineering Subjects.
6	5	1	40 to 49
23	17	6	50 to 59
22	19	3	60 to 69
16	5	11	70 to 79
11	9	2	80 to 90

MINIMUM, MAXIMUM, AND MEDIAN FIGURES: TOTAL NON-ENGINEERING SUBJECTS.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	40.7	40.7	42
Maximum.....	88.3	88.3	83
Median.....	64	62	71

Total Engineering Subjects.—The subsequent tables show the principal frequencies or modal tendencies in total engineering subjects including minimum, maximum, and median figures.

TOTAL REQUIREMENTS IN ENGINEERING SUBJECTS, ELECTRICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Sem.-hr. Credits Prescribed in Engineering Subjects.
8	6	2	60 to 69
16	10	6	70 to 79
30	25	5	80 to 89
14	9	5	90 to 99
8	4	4	100 to 111.5
1	0	1	121

MINIMUM, MAXIMUM, AND MEDIAN; TOTAL REQUIREMENTS IN ENGINEERING SUBJECTS.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	58	58	61
Maximum.....	121	106	121
Median.....	84	84	84

Specific Subjects in Electrical Engineering.—The following tables give the principal frequencies or modal tendencies in specific subjects in electrical engineering. In general the specific subjects include electrical instruments, electrical wiring, assembly and installation, principles of electrical engineering, alternating currents, direct currents, electrical engineering testing, alternating current machinery, advanced electrical machinery, alternating current design, direct current design, electric lighting, electric power transmission, trans-

former and induction motor design, telephone and telegraph engineering, radio engineering, dynamo laboratory, etc., industrial applications of electricity, and other similar specific subjects such as advanced courses in physics relating to electrical theory and measurements given in junior or senior years of college. The minimum, maximum, and median figures are also given.

SPECIFIC SUBJECTS IN ELECTRICAL ENGINEERING, ELECTRICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Sem.-hr. Credits Prescribed in Specific Electrical Engineering Subjects.
2	2	0	15 and 19
19	15	4	20 to 29
30	23	7	30 to 39
18	11	7	50 to 55

MINIMUM, MAXIMUM, AND MEDIAN; SPECIFIC SUBJECTS IN ELECTRICAL ENGINEERING.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	15	15	26
Maximum.....	55	55	54
Median.....	34	33	36

Requirements in Engineering Subjects other than Electrical Engineering.—The tables following show the principal frequencies or modal tendencies in other engineering subjects; also, the minimum, maximum, and median figures.

OTHER ENGINEERING SUBJECTS, ELECTRICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Sem.-hour Credits Prescribed in "Other Engineering Subjects."
1	1	0	17
1	1	0	26
33	22	11	30 to 39.5
25	19	6	40 to 49
13	10	3	50 to 59
4	2	2	60 to 69
1	0	1	73.3

MINIMUM, MAXIMUM, AND MEDIAN; OTHER ENGINEERING SUBJECTS.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	26	26	30
Maximum.....	73.3	63	73.3
Median.....	42	42	Bet. 38 and 41

Requirements in Engineering Electives.—The following tables show the principal frequencies or modal tendencies in the engineering electives of electrical engineering curricula, including also the minimum, maximum, and median figures.

ENGINEERING ELECTIVES, ELECTRICAL ENGINEERING CURRICULA.

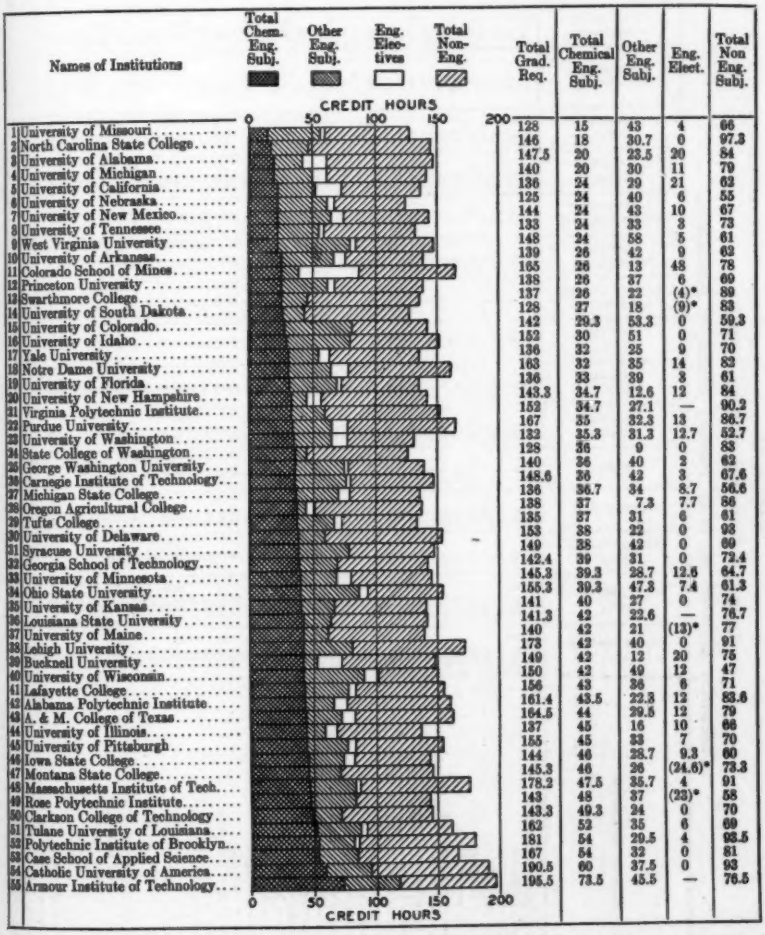
Number of Cases.	In Public Institutions.	In Private Institutions.	Sem.-hr. Credits Prescribed in Engineering Electives.
25	19	6	0
31	17	14	1 to 10
15	13	2	10 to 20
5	4	1	20 to 30
2	2	0	53 and 81

MINIMUM, MAXIMUM, AND MEDIAN; ENGINEERING ELECTIVES.

Requirements.	For All Institutions (78).	For Public Institutions (55).	For Private Institutions (23).
Minimum.....	0 or 3	0 or 3	0 or 1
Maximum.....	81	81	21
Median.....	Bet. 4.7 and 5.3	6	3

The foregoing tables show that approximately 32 per cent of all the engineering schools do not allow engineering electives (general options are not included in this statement).

E. Graduation Requirements in Chemical Engineering



	Names of Institutions	Total Grad. Req.	Total Chemical Eng. Subj.	Other Eng. Subj.	Eng. Elect.	Total Non Eng. Subj.
1	University of Missouri	128	15	43	4	66
2	North Carolina State College	146	18	30.7	0	97.3
3	University of Alabama	147.5	20	23.5	20	84
4	University of Michigan	140	20	30	11	79
5	University of California	136	24	29	21	62
6	University of Nebraska	125	24	40	6	55
7	University of New Mexico	144	24	43	10	67
8	University of Tennessee	133	24	33	3	73
9	West Virginia University	148	24	58	5	61
10	University of Arkansas	139	26	42	9	62
11	Colorado School of Mines	165	26	13	48	78
12	Princeton University	138	26	37	6	69
13	Swarthmore College	137	26	22	(4)*	89
14	University of South Dakota	128	27	18	(9)*	83
15	University of Colorado	142	29.3	53.3	0	59.3
16	University of Idaho	152	30	51	0	71
17	Yale University	136	32	25	9	70
18	Notre Dame University	163	32	35	14	83
19	University of Florida	136	33	39	3	61
20	University of New Hampshire	143.3	34.7	12.6	12	84
21	Virginia Polytechnic Institute	152	34.7	27.1	—	90.2
22	Purdue University	167	35	32.3	13	86.7
23	University of Washington	132	35.3	31.3	12.7	52.7
24	State College of Washington	128	36	9	0	83
25	George Washington University	140	36	40	2	62
26	Carnegie Institute of Technology	148.6	36	42	3	67.6
27	Michigan State College	136	36.7	34	8.7	56.6
28	Oregon Agricultural College	138	37	7.3	7.7	86
29	Tufts College	135	37	31	6	61
30	University of Delaware	153	38	22	0	93
31	Syracuse University	149	38	42	0	69
32	Georgia School of Technology	142.4	39	31	0	72.4
33	University of Minnesota	145.3	39.3	28.7	12.6	64.7
34	Ohio State University	155.3	39.3	47.3	7.4	61.3
35	University of Kansas	141	40	27	0	74
36	Louisiana State University	141.3	42	22.6	—	76.7
37	University of Maine	140	42	21	(13)*	77
38	Lehigh University	173	42	40	0	91
39	Bucknell University	149	42	12	20	75
40	University of Wisconsin	150	42	49	12	47
41	Lafayette College	156	43	36	6	71
42	Alabama Polytechnic Institute	161.4	43.5	22.3	12	83.6
43	A. & M. College of Texas	164.5	44	29.5	12	79
44	University of Illinois	137	45	16	10	66
45	University of Pittsburgh	155	45	33	7	70
46	Iowa State College	144	46	28.7	9.3	60
47	Montana State College	145.3	46	26	(24.6)*	73.3
48	Massachusetts Institute of Tech.	178.2	47.5	35.7	4	91
49	Rose Polytechnic Institute	143	48	37	(23)*	58
50	Clarkson College of Technology	143.3	49.3	24	0	70
51	Tulane University of Louisiana	162	52	35	6	69
52	Polytechnic Institute of Brooklyn	181	54	29.5	4	93.5
53	Case School of Applied Science	167	54	32	0	81
54	Catholic University of America	190.5	60	37.5	0	93
55	Armour Institute of Technology	195.5	73.5	45.5	—	76.5

Graph O. Total Semester-Hour Requirements in Principal Subject Groups, Chemical Engineering Curricula.

*Options—not included in Total Graduation Requirements.

TABLE IX.

Chemical Engineering, 1924–1925.

Graduation Requirements in 35 Publicly Controlled Institutions.

Names of Institutions.	Total Semester Hours.	Total Prescribed Hours.	Total Elective Hours.	Mathematics.	English.	Physical Science.	Social Science.	Foreign Language.	Physical and Military Training.	Miscellaneous Subjects.	Non-Engineering Electives.	Chemical Engineering.	Other Engineering.	Engineering Electives.	Total Non-Engineering.	Total Engineering.
1. Alabama Polytechnic Institute	161.4	149.4	12	20	16	30	5	6	6.6	0	—	43.5	22.3	12	83.6	77.8
2. University of Alabama	147.5	127.5	20	20	4	50	6	0	4	0	—	20	23.5	20	84	63.5
3. University of Arkansas	139	119	20	19	6	22	0	0	4	0	11[1]	26	42	9	62	77
4. University of California.[2]	136	115	21	12	—	34	2	—	8	0	—	24	29	21	56	74
5. University of Colorado.*	142	142	0	18	8.6	30.7	0	0	2	0	0	29.3	53.3	0	59.3	82.7
6. Colorado School of Mines	165	117	48	20	6	44	0	0	8	0	—	26	13	48[3]	78	87
7. University of Delaware	153	153	0	24	12	32	1	12	12	0	0	38	22	0	93	60
8. University of Florida	136	133	3	16	8	26	3	0	8	0	—	33	39	3	61	75
9. Georgia School of Technology	142.4	142.4	0	23.7	15	12	3	12	6.7	0	0	39	31	0	72.4	70
10. University of Idaho	152	152	0	18	10	26	0	9	8	0	0	30	51	0	71	81
11. University of Illinois	137	127	10	15	6	30	0	8	7	0	—	45	16	10	66	71
12. Purdue University	167	154	13	20	9	36+	3	12	6.7	0	—	35	32.3	13	86.7	80.3
13. Iowa State College.*	144	134.7	9.3	19.3	8.7	28	0	0	4	0	—	46	28.7	9.3	60	84
14. University of Kansas	141	141	—	20	8	30	6	10	—	0	0	40	27	0	74	67
15. Louisiana State University.*	141.3	141.3	—	16.7	12	32	0	12	4	0	—	42	22.6	—	76.7	64.6
16. University of Maine	140	122	18	16	12	31	—	—	—	—	18	42	21	(13)	77	63
17. University of Michigan	140	113	27	16	6	38[4]	3	—	—	—	16[5]	20	30	11	79	61
18. Michigan State College.*	136	121.3	14.7	16	8	17.3	1.3	—	8	0	6	36.7	34	8.7	56.6	79.4
19. University of Minnesota.*	145.3	132.7	12.6	16.7	6	28	0	14	—	0	—	39.3	28.7	12.6	64.7	80.6
20. University of Missouri	128	124	4	20	12	21	5	0	8	0	—	15	43	4	66	62
21. Montana State College.*	145.3	145.3	—	18	10	33.3	4	0	8	0	—	46	26	(24.6)	73.3	72
22. University of Nebraska	125	119	6	16	4	26	3	0	4	2	0	24	40	6	55	70
23. University of New Hampshire	143.3	131.3	12	22	6	36	0	12	8	0	0	34.7	12.6	12	84	59.3
24. Universtiy of New Mexico	144	122	22	18	9	26	—	—	—	2	12	24	43	10	67	77
25. North Carolina State College.*	146	128	18	20	12	37.3	2	0	8	0	18	18	30.7	0	97.3	48.7
26. Ohio State University.*	155.3	147.9	7.4	20	6	28.6	0	0	6.7	0	0	39.3	47.3	7.4	61.3	94
27. Oregon Agricultural College	138	130.3	7.7	16	6	30	6	18	10	0	0	37	7.3	7.7	86	52
28. University of South Dakota	128	128	(9)[6]	18	3	22	6	—	12	22	—	27	18	(9)[6]	83	45
29. University of Tennessee	133	124	9	20	12	25	0	0	10	0	6	24	33	3[7]	73	60
30. A. & M. College of Texas	164.5	152.5	12	22	16	24	9	0	8	0	—	44	29.5	12	79	85.5
31. Virginia Polytechnic Institute.*	152	136	16	20	12	28.7	8	0	5.1	.4	16	34.7	27.1	—	90.2	61.8
32. University of Washington.*	132	119.3	12.7	12	2	32	0	0	6.7	0	—	35.3	31.3	12.7	52.7	79.3
33. State College of Washington	128	128	0	16	8	44	8	0	7	0	0	36	9	0	83	45
34. West Virginia University	148	143	5	16	7	31	3	0	4	0	0	24	58	5	61	87
35. University of Wisconsin	150	137	13	18	6	23	0	0	—	—	—	48	53	12	47	103

* Figures have been reduced from term to semester hours.
[1] Subject to consent of authorities.
[2] Suggested curr. in chem. tech.
[3] Includes some non-engineering elect.
[4] Includes all chemistry courses.
[5] Language and other group.
[6] Option.
[7] Not definitely technical.

* Figures have been reduced from term to semester hours.
[1] Subject to consent of authorities.
[2] Suggested curr. in chem. tech.
[3] Includes some non-engineering elect.
[4] Includes all chemistry courses.
[5] Language and other group.
[6] Option.
[7] Not definitely technical.

TABLE IX.

CHEMICAL ENGINEERING, 1924–1925.—*Continued.*

Graduation Requirements in 20 Privately Controlled Institutions.

Names of Institutions.	Total Semester Hours.	Total Prescribed Hours.	Total Elective Hours.	Mathematics.	English.	Physical Science.	Social Science.	Foreign Language.	Physical and Military Training.	Miscellaneous Subjects.	Non-Engineering Electives.	Chemical Engineering.	Other Engineering.	Engineering Electives.	Total Non-Engineering.	Total Engineering.
1. Yale University	136	115	21	12	12	22	12	(12)[1]	0	0	12[2]	32	25	9+[2]	70	66
2. George Washington University	140	138	2	12	6	32	6	6	0	0	—	36	40	2	62	78
3. Catholic University of America	190.5	190.5	0	18	6	42	6	6	0	15	0	60	37.5	0	93	97.5
4. Armour Institute of Technology	195.5	195.5	(6)	18	9	35.5	10	0	—	4	0	73.5	45.5	(6)	76.5	119
5. University of Notre Dame	163	149	14	18	10	40	0	0	0	14	—	32	35	14	82	81
6. Rose Polytechnic Institute	143	143	(23)	17	8	17	2	10	4	0	—	48	37	(23)	58	85
7. Tulane University of Louisiana	162	156	6	18	12	31	6	0	2	0	—	52	35	6	69	93
8. Massachusetts Institute of Technology	178.2	174.2	4	11	12	44	6	6	12	0	—	47.5	35.7	4	91	87.2
9. Tufts College	135	129	6	13	6	22	6	12	2	0	—	37	31	6	61	74
10. Princeton University	138	132	6	9	8	24	14	12	2	0	—	26	37	6	69	69
11. Polytechnic Institute of Brooklyn	181	171	10	20	13	42.5	8	0	4	0	6	54	29.5	4	93.5	87.5
12. Clarkson College of Technology.*	143.3	143.3	0	16	6	28	16	0	4	0	0	49.3	24	0	70	73.3
13. Syracuse University	149	149	0	18	6	30	3	12	0	0	0	38	42	0	69	80
14. Case School of Applied Science	167	167	0	18	12	33	2	9	7	0	0	54	32	0	81	86
15. Lehigh University	173	170	3	15	3+	45	9	6+	6	4	3	42	40	0	91	82
16. Lafayette College	156	150	6	17	6	36	0	0	4	8	—	43	36	6	71	85
17. Bucknell University	149	129	20	17	10	40	0	6	0	2	(20)[3]	42	12	20[3]	75	74
18. Swarthmore College	137	133	4	21	9	21	12	18	—	4	4	26	22	(4)[4]	89	48
19. Carnegie Institute of Technology.†	148.6	145.3	3	18	6	21	18	0	4.6	—	—	36	42	3	67.6	81
20. University of Pittsburgh	155	148	7	14	14	30	4	0	4	4	0	45	33	7	70	85

* Figures have been reduced from term to semester-hours.
† Reduced from Carnegie Institute system to semester-hour credits.
[1] Highly recommended.
[2] Estimated.
[3] Electives are chosen from a list of both technical and non-technical subjects.
[4] Largely non-technical.

Analysis of Graduation Requirements in Chemical Engineering

Total Graduation Requirements.—There are thirty-seven different cases of total graduation requirements in chemical engineering in the list of fifty-five colleges of engineering included in this section of our study. These totals vary from 125 to 195.5 semester-hour credits.

The following tables show in terms of semester-hour credits the principal frequencies or modal tendencies of total graduation requirements in chemical engineering in 35 public and 20 private institutions; the minimum, maximum, and median figures are also given.

Total Graduation Requirements, Chemical Engineering Curricula.

Number of Cases.	In Public Institutions.	In Private Institutions.	Number of Graduation Requirements in Semester-hour Credits.
4	4	0	125 to 128
12	8	4	130 to 139
20	14	6	140 to 149
7	5	2	150 to 156
7	4	3	160 to 167
5	0	5	173 to 195.5

Minimum, Maximum, and Median; Total Graduation Requirements.

Requirements.	For All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	125	125	135
Maximum.....	195.5	167	195.5
Median.....	144	142	Bet. 149 and 155

Total Prescribed Credits.—The following tables show the principal frequencies or modal tendencies in the total prescribed semester-hour credits in chemical engineering including also the minimum, maximum, and median figures.

TOTAL PRESCRIBED CREDITS, CHEMICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Number of Prescribed Semester-hour Credits.
7	6	1	113 to 119.3
12	10	2	120 to 129
10	7	3	130 to 138
14	8	6	140 to 149
5	4	1	150 to 156
6	0	6	167 to 195.5

MINIMUM, MAXIMUM, AND MEDIAN; TOTAL PRESCRIBED CREDITS.

Requirements.	For All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	113	113	115
Maximum.....	195.5	154	195.5
Median.....	137	131.3	Bet. 148 and 149

Total Elective Credits.—The following tables show the principal frequencies or modal tendencies in the total elective semester-hour credits in chemical engineering and include also the minimum, maximum, and median figures.

TOTAL ELECTIVE CREDITS, CHEMICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Number of Elective Semester-hour Credits.
15	9	6	0
7	2	5	1 to 4
11	6	5	5 to 9.3
14	12	2	10 to 18
7	5	2	20 to 27
1	1	0	48

MINIMUM, MAXIMUM, AND MEDIAN; TOTAL ELECTIVE SEMESTER-HOUR CREDITS.

Requirements.	For All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	0 or 2	0 or 3	0 or 2
Maximum.....	27	48	21
Median.....	6	12	4

These tables show that 27 per cent of all the schools—26 per cent of the public and 30 per cent of the private institutions—offer no electives in the chemical engineering curriculum.

Requirements in Mathematics.—The following tables show the principal frequencies or modal tendencies for graduation requirements in mathematics, also the minimum, maximum, and median figures.

REQUIREMENTS IN MATHEMATICS, CHEMICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits Prescribed in Mathematics.
9	8	1	16
13	6	7	18
11	10	1	20

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN MATHEMATICS.

Requirements.	For All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	9	12	9
Maximum.....	24	24	21
Median.....	18	18	17

Requirements in English.—The following tables show the principal frequencies or modal tendencies for graduation requirements in English including the minimum, maximum, and median figures.

REQUIREMENTS IN ENGLISH, CHEMICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits Prescribed in Mathematics.
1	1	0	0[1]
16	9	7	6
6	4	2	8
11	7	4	12

[1] The University of California requires an examination in English.

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN ENGLISH.

Requirements.	For All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	0 or 2	0 or 2	0 or 3
Maximum.....	16	16	14
Median.....	8	8	8

Requirements in Physical Science.—The following tables show the principal frequencies or modal tendencies for graduation requirements in physical science, including also minimum, maximum, and median figures.

REQUIREMENTS IN PHYSICAL SCIENCE, CHEMICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hours Prescribed in Physical Science.
3	2	1	12 to 17
20	14	6	20 to 28.7
23	16	7	30 to 38
8	2	6	40 to 45
1	1	0	50

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN PHYSICAL SCIENCE.

Requirements.	For All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	12	12	17
Maximum.....	50	50	45
Median.....	30	30	Bet. 31 and 32

Requirements in Social Science.—The following tables show the principal frequencies or modal tendencies for graduation requirements in social science including the minimum, maximum, and median figures.

REQUIREMENTS IN SOCIAL SCIENCE, CHEMICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hours Prescribed in Social Science.
18	15	3	0
7	6	1	3
9	4	5	6

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN SOCIAL SCIENCE.

Requirements.	For All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	0 or 1	0 or 1	0 or 2
Maximum.....	9	9	18
Median.....	3	2	6

The foregoing tables show that nearly 33 per cent of all the institutions—40 per cent of the public and more than 10 per cent of the private institutions—do not prescribe social science.

Requirements in Foreign Language.—The following tables show the principal frequencies or modal tendencies for graduation requirements in foreign language, also the minimum, maximum, and median figures.

REQUIREMENTS IN FOREIGN LANGUAGE, CHEMICAL ENGINEERING CURRICULA.

Number of Cases.	Number of Public Institutions.	Number of Private Institutions.	Semester-hour Credits Prescribed in Foreign Language.
32	24	8	0
7	1	1	6
8	4	4	12

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN FOREIGN LANGUAGE.

Requirements.	For All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	0 or 6	0 or 6	0 or 6
Maximum.....	18	18	18
Median.....	0	0	6

These tables show that nearly 60 per cent of the institutions —70 per cent of the public and 40 per cent of the private institutions—do not prescribe foreign language for graduation in chemical engineering.

Requirements in Physical and Military Training, and Hygiene.—The following tables show the principal frequencies or modal tendencies for graduation requirements in physical and military training, including hygiene.

REQUIREMENTS IN PHYSICAL AND MILITARY TRAINING, INCLUDING HYGIENE, CHEMICAL ENGINEERING CURRICULA.

Number of Cases.	Number of Public Institutions.	Number of Private Institutions.	Semester-hours Prescribed in Physical and Military Training, Etc.
14	6	8	0
11	6	5	4
5	5	0	6.7
10	10	0	8

MINIMUM, MAXIMUM, AND MEDIAN; REQUIREMENTS IN PHYSICAL AND MILITARY TRAINING.

Requirements.	For All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	0 or 2	0 or 2	0 or 2
Maximum.....	12	12	12
Median.....	4	6.7	2

The foregoing tables show that only approximately 25 per cent of all of the engineering schools—17 per cent of the public and 40 per cent of the private—do not prescribe physical and military training, etc.

Requirements in Prescribed Miscellaneous Subjects.—Twelve of the fifty-five institutions under consideration prescribe certain subjects for graduation in chemical engineering in addition to those indicated above. These subjects include for the most part, Bible, religion, psychology, philosophy, and orientation courses. The lowest requirement is 0.4 semester-hour credit; the highest is 22.

Non-Engineering Electives.—Thirteen institutions of the fifty-five definitely indicate non-engineering electives as a part of the graduation requirements in chemical engineering.

Total Non-Engineering Subjects.—The following tables

show the principal frequencies or modal tendencies in total-non-engineering subjects; also the minimum, maximum, and median figures.

TOTAL REQUIREMENTS IN NON-ENGINEERING SUBJECTS, CHEMICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits in Non-engineering Subjects.
1	1	0	47
5	4	1	50 to 60
16	10	6	60 to 70
16	10	6	70 to 80
10	7	3	80 to 90
7	3	4	90 to 97.3

MINIMUM, MAXIMUM, AND MEDIAN; TOTAL REQUIREMENTS IN NON-ENGINEERING SUBJECTS.

Requirements.	For All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	47	47	58
Maximum.....	97.3	97.3	93.5
Median.....	72.4	73	Bet. 70 and 71

Total Engineering Subjects.—The following tables show the principal frequencies or model tendencies in total engineering subjects, also minimum, maximum, and median figures.

TOTAL REQUIREMENTS IN ENGINEERING SUBJECTS, CHEMICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits in Engineering Subjects.
3	2	1	45 to 48
2	2	0	52 to 59.3
11	9	2	60 to 69
15	11	4	70 to 79
18	8	10	80 to 87.5
5	2	3	93 to 119

MINIMUM, MAXIMUM, AND MEDIAN; TOTAL REQUIREMENTS IN ENGINEERING SUBJECTS.

Requirements.	In All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	45	45	48
Maximum.....	119	103	119
Median.....	77	72	Bet. 81 and 82

Requirements in Specific Subjects in Chemical Engineering.—The following tables show the principal frequencies or modal tendencies in the specific subjects of chemical engineering. For the purpose of this study all freshman and sophomore courses in chemistry have been counted as a part of the requirements in physical science in the non-engineering group. All other chemistry courses including those in applied chemistry are designated chemical engineering.

SPECIFIC SUBJECTS IN CHEMICAL ENGINEERING, CHEMICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits in Specific Chemistry Engineering Subjects.
2	2	0	15 to 18
13	11	2	20 to 29
19	13	6	30 to 39
16	9	7	40 to 49
3	0	3	52 to 54
1	0	1	60
1	0	1	73.5

MINIMUM, MAXIMUM, AND MEDIAN; SPECIFIC SUBJECTS IN CHEMICAL ENGINEERING.

Requirements.	For All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	15	15	26
Maximum.....	73.5	48	73.5
Median.....	37	35	Bet. 42 and 43

Requirements in Engineering Subjects other than Chemical Engineering.—The following tables show the principal

frequencies or modal tendencies in other engineering subjects, including the minimum, maximum, and median figures.

These subjects include all general subjects in engineering, in addition to specific subjects in mechanical, electrical, and civil engineering that may be prescribed in connection with the technical courses in chemistry or chemical engineering.

OTHER ENGINEERING SUBJECTS, CHEMICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits in Other Engineering Subjects.
2	2	0	7.3 to 9
5	4	1	12 to 18
16	12	4	20 to 29
19	8	11	30 to 39
10	5	5	40 to 49
4	4	0	50 to 58

MINIMUM, MAXIMUM, AND MEDIAN FIGURES; OTHER ENGINEERING SUBJECTS.

Requirements.	For All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	7.3	7.3	12
Maximum.....	58	58	45.5
Median.....	32	29	35

Requirements in Engineering Electives.—The following tables show the principal frequencies or modal tendencies in the engineering electives of chemical engineering curricula, including also the minimum, maximum, and median figures.

ENGINEERING ELECTIVES, CHEMICAL ENGINEERING CURRICULA.

Number of Cases.	In Public Institutions.	In Private Institutions.	Semester-hour Credits in Engineering Electives.
19	12	7	0
21	10	11	2 to 9.3
11	10	1	10 to 14
3	2	1	20 to 21

MINIMUM, MAXIMUM, AND MEDIAN; ENGINEERING ELECTIVES.

Requirements.	For All Institutions (55).	For Public Institutions (35).	For Private Institutions (20).
Minimum.....	0 or 2	0 or 3	0 or 2
Maximum.....	48	48	20
Median.....	5	7.4	4

These tables show that more than 34 per cent of all the engineering schools—34 per cent of the public and 35 per cent of the private institutions—do not allow engineering electives (this does not refer to group options).

THE DEVELOPMENT OF ENGINEERING EDUCATION DURING THE LAST FIFTY YEARS.*

BY MORTIMER E. COOLEY,

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In accepting your invitation to prepare and deliver this address I fear my sense of duty and my appreciation of the compliment outweighed my abilities and my discretion. It seemed a simple task to tell the story, in a sense the story of my own life, as I have myself lived in the midst of engineering for more than fifty years and have been a teacher of engineering for more than forty-five years. In that time have come about the many developments in engineering education and practice which have brought the world to its present state of civilization, a state unknown we are prone to believe in all time past.

But who shall say positively that this is true, since Flinders Petrie, the great Egyptologist, has told us of six successive civilizations in the past 10,000 years; since the explorations of archeologists in recent years have uncovered remains of engineering works that in their minor aspects would be no mean achievement to-day, and in their major aspects could justly be pointed to with pride. True, the word engineer, as we think of it, was unknown. Nor should it matter. The works themselves are the best evidence that engineering was then, as to-day, the material means to the state we designate as civilized. Examples of that evidence were the Seven Wonders of the world, the achievements of the Romans, the Greeks, the Egyptians, the Assyrians, the Babylonians, and on back through dim and dark ages to the very beginning when God created the heavens and the earth as told in the Book of Genesis. And who shall deny it when philologists tell us that

* Address delivered at the Semi-Centennial Celebration of the A. & M. College of Texas, October 15, 1926.

the G-E-N of Genesis and the G-I-N of engineers are from one and the same root, meaning *to create.*

In this look backward we can only generalize from examples here and there as to engineers. Then as now they were modest, preferring to let their acts speak for them. Old writings contain much about rulers of men, warriors, poets and sages, and something of what was accomplished in the building of temples and tombs; and they are mentioned by name and title. Not so the engineer who designed and carried into execution the projects demanded of him. Why?—let me ask, and give as my answer that the things done by the engineer were in the main necessities for the life of the time, and being lived with constantly were taken as matters of course. True then, as now, familiarity, while not breeding contempt, bred expectancy of the realization of the conveniences of life. Now, if not then, the scope of the engineer's work embraces many of the luxuries of life as well as the necessities. Some day, let us hope, (when the data shall be more complete) will come a man to write a history of the great engineers of the past and their triumphs, not so much for the credit of a great profession as for the pride of our younger engineers who will regard it as their heritage. It would increase their sense of responsibility in the progress of civilization, and what is more important, perhaps, result in a better understanding and greater appreciation of the service rendered.

Practically all formal engineering education, particularly in this country, dates from early in the nineteenth century. First was the U. S. Military Academy at West Point proposed by General Henry Knox, seconded by Alexander Hamilton and approved by General Washington in 1776, and authorized by Congress in 1802. While its training was for military purposes, this school must be mentioned because of the large number of its graduates who have been eminent in civil as distinguished from military engineering. The Rensselaer Polytechnic Institute at Troy, N. Y., founded in 1824, may justly claim to be *alma mater* in civil engineering. Union College

in 1845 organized courses in civil engineering under Wm. Mitchell Gillespie. Among state institutions the University of Michigan, founded in 1837, provided in its Organic Act for a professorship in civil engineering. Not until 1853, however, was the chair filled and then by the professor of physics. He was followed by Wm. Guy Peck of West Point in 1855, who in turn was followed by DeVolson Wood in 1857. The first class was graduated in 1860. The Lawrence Scientific School, established at Harvard in 1847, offered work in engineering, mining and chemistry. But mining engineering came formally into the field with the founding of the Columbia School of Mines in 1864.

While we ordinarily think of civil engineers as marking the beginning, we must not overlook the fact that long before them came the surveyors, the pioneers in engineering. George Washington was a surveyor. Surveying, as it involves knowledge of geometry, trigonometry and astronomy, found a ready place in the classical college. As showing the rapidity of development of engineering education, once it was separated from the classical, only about forty years elapsed before civil engineering began to send out shoots that grew to branches. Mechanical engineering became known as such with the founding of Stevens Institute of Technology in 1867 and the establishment of its courses of instruction in 1870. At about the same time (1868) mechanical engineering was established at the University of Michigan, but later was merged with civil engineering and was not again separately announced until 1881. Meantime mechanical engineering was being emphasized in a number of institutions,—Cornell, Worcester Polytechnic Institute, Massachusetts Institute of Technology and elsewhere.

In the late 70's and early 80's rapid strides were being taken in the field of electricity and magnetism. As for engineering generally the foundation work was done in the department of physics. In the late 80's electrical engineering as a new branch was grafted onto the engineering tree. Ten years afterward came another branch, chemical engineering,

to be followed by agricultural engineering in some of the Land Grant Colleges, and in a few schools by textile engineering, marine engineering and now by the latest, aeronautical engineering. Of particular interest at this time when the federal and state governments are engaged in a topographical survey of the country, and contemplating more accurate boundary surveys, is the establishment of separate departments of geodesy and surveying. Each of these main branches has in turn put forth its own numerous branches until now there are twenty-five or thirty subdivisions in engineering with their several curricula, some of them more extensive even than was the parent trunk from which they sprang.

These subdivision curricula are usually in the form of groups of studies elective for upper classmen. In civil engineering there are, for instance, structural, hydraulic, railroad, transportation, sanitary, municipal, highway, highway transport and traffic groups. In mechanical engineering: steam power, internal combustion, hydro-mechanical, heating and ventilating, refrigerating, automobile and industrial groups. In electrical engineering: communication, power, railway, and illumination groups. In chemical engineering: metallurgical, gas, organic industrial, general manufacturing, pulp and paper manufacturing groups. In marine engineering: naval architecture and marine engine groups. In aeronautical engineering: lighter than air and heavier than air groups. In geodesy and surveying: plain surveying and geodesy groups.

In this rapid survey of engineering education we see that formal instruction has been given for but little more than one hundred years. Before the war between the states and for some time after, engineering instruction was for the most part given in colleges of literature, science, and the arts. Its status was substantially the same as for the languages, history, philosophy, mathematics, physics and chemistry. It could hardly be said to be a professional status. The second interval, from 1865 to 1900, marked transition to the professional stage. The third stage, that since 1900, has seen a

marvelous development, a carefully planned response to the industrial demands of our country. The result has been to place us as a people at the forefront of the nations of the earth in the production of wealth.

But the credit is not to engineers alone. In order to keep our vision clear let me here pay tribute to those other workers, particularly in the field of pure science. They explore new fields and blaze the trails into them. Engineers follow, convert trails into highways, bring in capital and commercialize the discoveries in pure science. Thus the engineer is an applied scientist. During the first half and well into the third quarter of our century of more or less formal engineering education, capital was exceedingly timid and ventured into fields discovered by the pure scientist only when completely assured of success. Things had to be *practical* in order to appeal to the hard-headed business man. It was the engineer who bridged the gap between theory and practice.

It is not part of my task to set up in detail the various steps in the development of engineering education from the beginning down to now. That has already been done by other writers and by the Society for the Promotion of Engineering Education in what I think must be considered the most remarkable investigation in the field of education ever undertaken. Its findings will soon be in print and available to those who would step where I am leaping. My object is to take a back-sight, as it were, over the entire field and then reverse my telescope and try to look ahead into the future of engineering education. Unless my vision be distorted I shall hope in that way to contribute something of value to the engineering profession, and maybe of even greater value to our people in whose service engineers labor. But I am none too sanguine of being able to touch bottom in the sea on which we in this country are sailing. Even though rocks ahead be seen and their danger recognized, we shall sail on hopeful to escape them and bring our ships loaded with their riches into port where await them with outstretched arms a people ever craving more and more luxury.

It is a privilege accorded men of years to indulge in reminiscence. One of the vivid recollections of my first years of teaching is of the debates of the classicists and the scientists in faculty meetings. At the beginning of the year, once routine business was dispatched, a resolution was proposed for debate: Resolved that the classics are more important than the sciences. The debates continued throughout the year. As was to be expected the classicists, outweighing the scientists in numbers, also outweighed them in words. They were noble battles. Finally towards the end of the year a group of gentlemen who had graduated in the classics and later studied in the sciences, took part in the debates arguing from both sides with the result that the resolution was laid on the table until next year. I have thought many times how much better it would have been had some middle ground been found, so that to-day we should not be as one-sided in the sciences as we were formerly in the classics but be better poised for the great problems swooping down upon us.

Fifty years ago the graduate in engineering was of necessity broadly trained. There were few books on engineering subjects and all those studied could be carried under one's arm—less than half a dozen. In order to complete the number of hours required to graduate, the engineering student had to choose from history, philosophy, and the languages. Geology, mineralogy and astronomy were required, as of course were mathematics, physics and chemistry. Thus the engineer of those early days was much more a man of affairs than now. His training developed an individuality which disposed him to come into more direct contact with the general public. Thus he was better known. One has only to recall the names of some of the earlier engineers to realize how true this is. Gradually, as engineering extended into new fields, required study increased and one by one literary subjects had to be dropped to make room for it. Not only that, but the number of hours required to graduate had to be increased from 120 to 140 and more. A thesis was also required. To-day, then, our engineering curricula are as unbalanced at the other extreme

as they were during the classical period. Instead of being broadly trained, the engineer has become a specialist. His training no longer fits him for the rôle of a man of affairs.

Here again I may be reminiscent. Before the World War an employer of some 60 or 70 graduates from several of our leading engineering schools complained that we were not fair in our training of men for the industries—not fair to the young men themselves or to their employers. He had no fault to find with the quality of our teaching which he said splendidly fitted them to work in the lines taught them. "But," he said, "these young men can't do anything else. We can get all we want of such as you graduate at nominal salaries. What we need are men who can command higher salaries, who instead of a maximum of $5,000 or $6,000 are in line for $25,000 or $30,000. Such men the colleges are not turning out. We need men of affairs, who when the time comes can take responsible charge in the highest positions in industry." This view of engineering education expressed more than a dozen years ago is, I think, now becoming common in the industries.

In further illustration of the attitude of employers towards engineering graduates, let me relate an incident of nearly forty years ago. An employer said to me, "I have finished with Michigan men. They can't do anything practical. I am going to try eastern graduates." A few years later he came to me and said, "I am back again to Michigan graduates. I have tried half a dozen schools and they are all alike." In forty years there has been a wide swing of the pendulum. From a complaint that engineering graduates could not do anything practical we have now the complaint that they are too practical; while they can do well the thing taught them, they can't do anything else. Forty years ago it was difficult for an engineer graduate to find his first job. To-day there are often available to him as many as three or four to pick from. Forty years ago the young engineer commanded on graduation a salary of about $600 a year. To-day minimum beginning salaries are as high as $1500.

The age in which we live may be called the power age. It started with the steam engine of James Watt at about the time of our Revolutionary War, only about 150 years ago. The internal combustion engine came into existence just prior to our Civil War, about 75 years ago. Water power has been used much longer but until comparatively recently only in a minor way. Its modern development has come about through electrical transmission. Formerly the mill went to the water power. Now the water power comes to the mill. This power age, if divided into coal, petroleum (including natural gas) and water power, admits of more fundamental discussion, particularly with respect to the future. But first let us take a broad look at the past.

Dr. Pearl gives the population of the earth in 1800 as 850 millions and says that was probably the greatest number up to that time. In 1900 the population was 2 billions. It increased two and one-half times in 100 years. That is perhaps the most significant result of the power age. Two and one-half blades of grass had been made to grow where only one grew before and population follows food. Another result has been to make man power vastly more effective. One man to-day does the work of many fifty years ago. Out of that fact has come reduction of hours of labor with increased leisure. Also have come great social problems. Out of it, too, has come the amassing of great fortunes for corporations and individuals. In this century of engineering education the wealth of the world has been increased many fold. The rate of increase itself increased with more complete organization until now it has reached phenomenal heights. And what of the future?

The almost complete overhauling of engineering curricula twenty-five years ago was to meet the demand of industry in its rapid development in many fields. That these demands were met the results fully attest. The prime need, as engineering educators saw it then, was specialization. Students themselves were impatient of all study that did not bear directly on their future work. None realized that any penalty

might be involved, or if he did, gave it but little thought. We have all been sailing with the current on the crest of a tidal wave. Tides recede and rivers flow into the ocean where the mean sea level is constant. Thus we may know with all the certainty that comes from knowledge of natural laws that artificial conditions can not be maintained indefinitely and that sooner or later we must come back to normal. And in the swing back we may expect to go beyond the normal, to the other side.

I would not have you think that anything I may say is bred of pessimism. I much prefer that my utterances be regarded as opinions based on many years of observation under conditions that should give them some weight. An engineer who after careful examination of a project renders an adverse report is not considered a pessimist, though it must be admitted his fee is paid far more cheerfully for a favorable report even though it be not in accordance with the facts. Many leaders in education, prominent men of affairs and distinguished writers are calling attention to conditions and yellow warning signals are showing. Shall we heed them or wait for the red flash commanding halt? Shall even that be ignored because we are asleep or drunk at the wheel?

There is need of a different education for everyone if we are to meet the problems of the future and solve them in the interest of all mankind. Of that I am convinced. But I shall confine what I say to engineering education. Of first importance is our increasing population. We have seen an increase from 850 millions to 2 billions between 1800 and 1900. At the rate of increase since 1900, Dr. Pearl estimates that by 2000 the population will reach the limit of the earth's feeding capacity. He utilizes all arable land, improved methods of agriculture, and allows 2½ acres per man, woman and child. In the United States, Dr. Pearl says, the limit will be reached by 1960 or soon after. This is almost impossible of belief, particularly down here in Texas which doubting people in the north claim can alone feed the entire United States. Whether future population estimates be accurate or

not, the important fact is that we are increasing in numbers in some sort of geometrical ratio while food is increasing in arithmetical ratio. Sooner or later the population curve must meet the food curve. If it crosses we must revise our mode of living.

Of equal importance are our diminishing natural resources. Professor Fenneman in his remarkable address before the American Association for the Advancement of Science (1924) has classified them in four divisions:

"(*A*) Materials and sources of power which exist in abundance for all foreseeable time, such as common salt, brick clay, sunlight and nitrogen.

"(*B*) Resources permanent in their nature but limited in amount, like soil and water power.

"(*C*) Resources that are reproduced in crops, renewing themselves regularly and permanently if not exterminated, *e.g.*, fish, forests, and various animals.

"(*D*) Limited accumulations not replenished at an appreciable rate. When gone they are gone forever. Here belong important mineral resources, particularly coal and most of the ores."

For the purpose of this address we need consider only a few, keeping in mind that the object is to show the need of a different education. Starting with the Java man as the first evidence of civilization 500 thousand years ago, Fenneman says: Man has been half a million years discovering nature's bonuses, and now that they are discovered they will not last half a thousand. What will we do then? he asks, and answers: go back to work. Could there be a more disquieting statement? Let us try to comprehend it. It is common knowledge that the petroleum supply from pools will be exhausted in a dozen years or so, and that then we shall have to go to the shales at much higher costs. It is less commonly known that the pockets out of which we now get most of our iron ores are approaching exhaustion and that when gone we shall have to depend on rock ore at vastly greater cost in labor.

It is commonly said that we have 2000 years' coal supply at the rate of coal consumption during the past 25 years.

But let us look ahead a hundred years. The population being then doubled the consumption would be doubled, which cuts the 2000 years to 1000. But the consumption per capita has been increasing in approximately geometrical progression. If it merely doubles again, the 1000 years is cut to 500. Nor is that all. The price of coal has trebled in 25 years with no thought of the end in sight. What will happen when the end is in sight? Obviously the price will go far beyond the ability of most people to pay. With our forests gone and no fuel to warm our homes in the north lands people must flock to the south land in winter time. Then indeed would Texas come into its own and all would pray that it might be true that your empire state could house and feed our entire population.

"It requires a good imagination to visualize life even in the twenty-first century," says Fenneman, and further says that "when confronted with the elementary facts the unthinking man consoles himself with 'Oh, science will discover something.' The less a man knows of the conservation of energy the more satisfying this faith is. Some of us call it optimism, some faith, some superstition, and some plain ignorance. There is an optimism that elevates and there is an optimism that degrades and leads to ruin. . . . Science is still standing in reverie before these problems as it stood before most of them twenty years ago and twenty years before that."

Even so, there is the never ceasing need of research in science to the end that so far as is humanly possible we shall be ready to meet emergencies when and as they arise. A favorite answer to the question of diminishing fuel supply is utilization of water powers. We have 50 millions water horse power of which only 10 or 12 millions are in use. It seems that our water powers should go far towards helping out the coal supply, and figures go to prove it. Reduced to a coal basis, allowing 2 lbs. per horse power, 50 million horse power equals 438,000,000 tons per year. Loaded on cars 40 feet long each holding 50 tons it makes a train 66,365 miles

long. Such a train would girdle the earth 2½ times, and at 20 miles per hour require 4½ months to pass by. Yet, it is only a fraction of the total coal used to-day—a still smaller fraction of the coal that will be used in the future with increased population and ever increasing rate of consumption.

But that is not the worst of it. The streams upon which we shall depend for water power, irrigation and cheap transportation are being destroyed with the destruction of our forests. The protection against erosion afforded by root growth being removed, the streams are filling with soil and silt. Then there are the floods, with which we are all familiar, and which periodically for thousands of years have inundated treeless China. Shall we remain supine with the lessons of the world before us? Shall we be content with a reforesting program which at the rate of 40,000 acres of replanting per year will require 2000 years to cover our more than 80 million acres that will raise trees and nothing else?

Two thousand years is a longer period than since the time of Christ. A forest reaches the harvest stage in about 100 years. Before us are the examples of France and Germany each with a quarter of its area in forests, and Japan planting at the rate of 135 thousand acres per year. Shall we remain heedless when foresters tell us that 20 acres of an 80 acre farm in trees would furnish fuel enough to keep the family that could live on 80 acres warm and comfortable without disturbing the timber crop? May not in that fact alone be the answer to our coal problem? If so, then is not the restoration of our forests the most vital problem confronting the American people to-day?

I have cited these illustrations for their bearing on what I conceive to be the requirements of education during the next quarter century. The past quarter century has been a period of development—wonderful in its scientific and engineering achievements, disquieting if not actually alarming in its consumption of nature's bonuses. Untold wealth has become ours both in money and leisure. The thoughtful will, I think, agree that we have had more of both than is

good for us as a people. During the next quarter of a century we must learn to conserve and take steps to restore, as far as possible, the havoc due to our ignorance, to our greed.

Education's problem is to plan curricula that shall teach the fundamental facts that have come down to us out of previous civilizations, and which, by the law of analogy (human nature being always much the same) must apply to us unless we take steps to head them off. In engineering education, including the sciences, there must remain the highly specialized training that will enable us to wrest from nature her secrets and be prepared for great emergencies that are bound to arise. There must also be a broad training to enable us to comprehend the nature and extent of problems affecting our life and happiness when many of the things we now enjoy have become exhausted, and a philosophy to meet them.

Our civilization being so largely mechanical it devolves upon the engineer, an one expected to know, to make clear the facts which all must understand if we are to attain any measure of success in meeting them. Thus the engineer must have training better fitting him to exert influence on his fellows through personal contacts. Such a training, coupled with the professional knowledge he now has, would enable the engineer to render a vastly greater service than up to now, great as that service has been. The world could get along very nicely for a spell without a single new invention or improvement. But it can not get along with continued ignorance or heedlessness of facts essential to our welfare in the future, a future that is none too far away.

This broader education is too much to expect of all who would study engineering and devote only four years to it. Nor is it necessary even if it were practicable. Using the term engineer in its present comprehensive sense we might profitably consider that technical high school graduates are well fitted for very many industrial positions without going any farther. As only about one third of those who enter college in engineering graduate, we might consider the first

two years as a two-year course specially qualifying men for other positions in industry requiring no further training. There would remain, as now, the four-year course leading to the B.S. degree, after which would come another year or two leading to a higher degree.

But the curricula of these three college divisions would in this plan be materially different from now. There would in general be less technical work in both the two-year and the four-year programs. That is, the present required technical work would be spread over five years, say, giving the equivalent of a full year for study of subjects eliminated from the curriculum of fifty years ago. Beyond the fifth year specialization could be carried to any desired extent. If the leading colleges among our 150 engineering schools should agree upon a five-year program over which the technical work of the present four-year curricula should be spread, there would speedily come about the accomplishment of what I feel is a much needed reform in engineering education.

But I should not favor standardized curricula. That, I think, should be avoided. There can be too much standardization. Even if desirable in a machine-made product, why apply it to the human product? To take away from life individuality and the special gifts of nature would be to rob us of our heritage. If we can only shape our education along right lines we shall be able to accustom ourselves to live the simpler life in store for us, "not," as Fenneman says, "in detail like that of our fathers, but less complex and distracting than our own. According to his temperament the observer may look for a subsidence of the intellectual level or for a great blooming and fruiting in the realm of mind." In any case we shall be prepared to make the most and the best of whatever is in store for us.

In summation, we have seen that as the result of fifty years of engineering education the population of the earth has increased until the end of its feeding capacity is in sight; also the end of natural resources that have contributed so greatly to our wealth and made available comforts and pleasures un-

dreamed of before. Mere prudence commands that we project our vision into the future. It behooves us in all fields of education to impart to the youth of to-day knowledge and understanding that will enable them to face the future intelligently. They in turn must impart to the youth of to-morrow wisdom and strength to cope with conditions that will involve much greater strife to live and at their very best provide necessities where now are pleasures to satiety.

Failing in this, we educators stand to be charged in the future with having failed in our duty. Indeed education itself stands to face the bar of future judgment. It is the only new force our civilization has contributed to those known to exist in the past. If it fail, then logically must not our civilization follow after those that have gone before? But education can not fail. It *must* not fail. It *will* not, SHALL not fail.

NOTES ON THE MEETING OF REPRESENTATIVES OF ENGINEERING COLLEGES CALLED BY THE BOARD OF INVESTIGATION AND COÖRDINATION AND THE DIVISION OF DEANS AND ADMINISTRATIVE OFFICERS, WASHINGTON, D. C., NOVEMBER 18TH AND 19TH, 1926.

The meeting was called for the purpose of receiving and discussing the first installment of the final report of the Board of Investigation and Coördination in which the Board presents findings and recommendations resulting from the three year stage of fact-finding of the Society's Investigation of Engineering Education. The meeting was also called to inaugurate the second stage of the Society's undertaking, which will be devoted to putting into effect the results of the first stage of the work.

The meeting was attended by 134 individuals, comprising 18 presidents, 73 deans and 25 professors representing 91 colleges and universities, and 17 others representing various professional societies, educational foundations, the U. S. Bureau of Education, and industries.

The first session, held on the evening of November eighteenth at the Hotel Willard, was a dinner tendered by the Board of Investigation and Coördination to the assembled delegates. Professor Charles F. Scott of Yale University, Chairman of the Board, presided at the dinner. One member of the Board or Staff acted as host at each of the tables.

Professor Scott, in introducing President Frank Aydelotte, the principal speaker of the evening, briefly recounted the events leading to the inception of the Society's Investigation, spoke of the completion of the fact-finding stage and emphasized the importance of bringing to fruition the results of the work already done by concerted action on the part of college faculties and administrators.

The address of President Aydelotte is printed on other pages of this number of the JOURNAL.

Following President Aydelotte's address, Mr. Alfred D. Flinn, Director of Engineering Foundation, told of the steps which are being taken to finance the Investigation during the stage of constructive action, which will occupy the next two years, and requested those present to assist through suggestion and action in raising the funds.

Copies of the report of the Board of Investigation and Coordination and of the first nine bulletins which present the results of the fact-finding stages of the Investigation were distributed at the close of the dinner so that they might be studied before the opening of the sessions of the following day.

The morning and afternoon sessions of November nineteenth were held at the National Academy of Sciences. Dean M. S. Ketchum, of the University of Illinois, Chairman of the Division of Deans and Administrative Officers, presided.

Each of the seven sections of the Board's report, which were devoted to

1. Structure of Undergraduate Engineering Curricula
2. Social and Economic Content of Engineering Curricula
3. Admissions
4. The Non-Graduating Student
5. The Work of Exceptionally Gifted Students
6. Teaching Personnel
7. The Scope of Engineering Education

was introduced and briefly explained and discussed by W. E. Wickenden, Director of Investigation. Mr. Wickenden's remarks regarding each of the divisions of the Board's report were followed by general discussion from the floor. These discussions were introduced by the following individuals:

Structure of Undergraduate Engineering Curricula—President C. R. Richards, Lehigh University.

Social and Economic Content of Engineering Curricula—Dean A. A. Potter, Purdue University.

Admissions—President H. S. Boardman, University of Maine.

Teaching Personnel—Dean Charles H. Warren, Yale University.

Non-Graduating Student—Dean G. B. Pegram, Columbia University.

The Work of Exceptionally Gifted Students—Professor D. C. Jackson, Massachusetts Institute of Technology.

Following the remarks of each of these speakers there was general discussion during which the Director answered numerous questions as to the specific recommendations of the Board.

At the conclusion of the morning session, the draft of a booklet descriptive of engineering education and the field of engineering, which is intended as a guide for high school students who are considering the selection of engineering as a vocation, was distributed. This booklet was prepared by a committee of the Division of Deans and Administrative Officers, consisting of Dean R. L. Sackett, of Pennsylvania State College; Professor F. V. Randolph, of George Washington; and Dean F. L. Bishop of the University of Pittsburgh.

At the opening of the afternoon session, this booklet was discussed and it was voted that the Board of Investigation and Coördination be invited to coöperate in editing and completing it.

The discussion of the Board's report was then resumed. It was concluded by a description by H. P. Hammond, Associate Director of Investigation, of the means proposed for the consideration of the recommendations of the Board by faculty committees on educational policy. A memorandum was distributed which gives suggestions regarding the organization, personnel and programs of the proposed committees.

At the conclusion of the afternoon session the Committee on Resolutions, consisting of

A. A. Potter, Chairman
G. C. Anthony
J. R. Benton
S. S. Edmands
C. H. Fulton
P. R. Kolbe
J. F. Merrill
C. H. Warren

presented the following resolutions, which were unanimously adopted:

1. That we endorse the preliminary report of the Board of Investigation and Coördination as submitted at the Washington conference, November 19, 1926.
2. That we express our appreciation to the Board and Staff for the quality, character and practicability of this report.
3. That we recommend to the faculties of engineering colleges the immediate and thorough study of the details of this report, with the view of utilizing the findings in improving engineering education.
4. That we endorse the steps which are being taken by the Board to continue the Investigation and the plan of supplementing the first stage of fact-finding and analysis by a second stage of application as outlined at the conference in the recommended Plans for Further Action and especially the proposed work by college committees on educational policy.

ADDRESS TO REPRESENTATIVES OF ENGINEERING COLLEGES AT WASHINGTON, D. C., ON NOVEMBER 18TH, 1926.

BY FRANK AYDELOTTE,

President of Swarthmore College.

The Board of Investigation and Coördination of the Society for the Promotion of Engineering Education is now prepared to make the first installment of its report on the coöperative study of engineering education which has been financed for the last three years by the Carnegie Corporation. An outline of one part of this report digested under seven heads will be put into your hands this evening for your study, and you will be asked to discuss these points one by one tomorrow.

The suggestions which the Board is offering for your consideration are based upon facts and upon summaries of opinion collected during the last three years. The Director of the investigation, Dr. Wickenden, and the members of the Board are well aware that the collection of facts and the making up of tables and statistics do not preclude the necessity for thinking, but the Board feels that a knowledge of the facts in a case such as this does offer a good basis for thought. During the three years spent in this study it has become quite clear to the members of the Board that a good deal of the thinking about engineering education and the planning of engineering courses has been done without much reference to facts, especially without much reference to the aptitudes and capacities of engineering students and to the work in which they are going to engage after their graduation. Stated in engineering terms the manufacturing process has been carried on with too little reference to the nature of the raw material and to the use to be made of the finished product.

A careful report of the fact-finding stages of the investigation written by the Associate Director, Mr. Hammond, has

already been placed in your hands. I shall not try to summarize it in detail, but I might point out that the first and most important conclusion which the Board has drawn from these facts is that engineering education in this country on the whole can be said to be fairly effective. If a young man is preparing for the practice of engineering and is able to take an engineering course either in one of our better engineering schools or in a similar institution in any other country in the world, it would be difficult to say to him that by going abroad he would be likely to get a better training. The best of our engineering graduates are extremely successful both in the more technical and expert practice of engineering and also in the more diversified and less technical but no less exacting field of administration. It is a tradition of our engineering schools that undergraduates in them must work hard. It is taken for granted, at least in most of them, that the liberal elements of their training are as important or nearly as important as the scientific and the technical elements. It can be said of our best engineering training that it is a good education for a man even if he never goes into the practice of engineering. Probably the best comment on our engineering course in this country is that it compares extremely well with the ordinary course in liberal arts but that it does not compare so well with the training given in our professional schools of law and medicine.

It is not surprising that this should be the case. The training for law and medicine is longer. Furthermore, it seems not quite clear in the minds of our engineering faculties whether the task which they are doing should be compared with that which is being done in the college or with that which is being done in the professional school. There is a certain element of confusion, of uncertainty of purpose, which ought to be cleared up. We are like a golfer who, with his club in his hand and a stream across the fairway a hundred and fifty years ahead, is uncertain whether to play safe with careful attention to direction and to stop on the fairway on this side of the stream, or whether to put every ounce of effort into the

blow in order to carry the obstruction. Sometimes we stop short in safety sometimes we carry the stream and land safely on the green; but sometimes we fall into the water.

With all its merits our engineering training is capable of great improvement. It does not need to be revolutionized; it does not need to be taken to pieces and put together again; but it is susceptible of improvement in almost every detail, and even a small improvement would make a great difference. In dealing with such a delicate thing as an educational program conducted for the benefit of a highly selected group of students an improvement of ten per cent would make an enormous difference, and an improvement of twenty-five per cent might double the value of what we are doing. If we could do just a little more to make certain that the students whom we admit are those who really ought to be admitted, if we could do something to safeguard from total loss those who fall by the wayside during their course, if we could give just a little better opportunity to that small class who stand at the top, if we could do something to make the organization of the curriculum a little more effective, if we could make the conditions of engineering education a little more attractive so as to improve our teaching personnel, the sum total of all these slight improvements would raise the level of the profession of engineering to an extent which would surprise us all.

It is suggestions of this nature that the Board of Investigation and Coördination wishes to offer for your consideration. We are not prepared to solve for you the problems of engineering education. We have no ideal, standardized engineering course which we are asking you to adopt. We have not been able to work out the ideal engineering course nor have we met anyone who seemed to us to have penetrated to that secret. We are, on the whole, inclined to distrust those who think they have. We are not presenting you with solutions of your problems but are trying rather to formulate the problems for your discussion and experiment. What we are asking from you is coöperative thinking and constructive work.

Our first suggestion is that you should discuss these prob-

lems with your faculties at home. We hope to be able to suggest topics for faculty discussion and avenues for faculty experimentation. We then hope to collect the results of such discussion and experiment and to make them available for all.

But we are not so sanguine as to expect that the solutions which prove satisfactory for one institution will necessarily work in another. It is not part of our purpose to standardize engineering education in the United States. We have perhaps gone too far in that direction already. There are many signs that what we need now is not more standardization but more differentiation. But even if that be true, it is only on a basis of common ideals that differentiation can be made intelligently.

You will find in the analysis which we have made of the problem of engineering education a great deal which runs parallel to the excellent "Study of Engineering Education" by Dr. C. R. Mann, which was published by the Carnegie Foundation in 1918. It is a great pleasure to me to pay a tribute at this time on behalf of our Board to the high quality and the educational wisdom of Dr. Mann's report. One of the things that we are most anxious to do is to bring it about that more of the suggestions made by Dr. Mann should be put into practice. In our opinion this is more likely to come about if we can first of all in our meeting tomorrow and after that in your various faculties, have some fundamental discussion of the problems of engineering education. It seems to us that the principal difficulty is not to hit upon the right solution of the problems which engineering training presents but rather to get engineering faculties to consider these problems not from the point of view of individual departments and subjects but rather from the wider point of view of engineering education as a whole.

We wish to propose for your discussion in the first place, a subject which you will hardly exhaust in the time allowed for it tomorrow but which is central in all the work which we are trying to do. Can a successful engineering curriculum be made up by our present method of thinking in terms of indi-

vidual subjects, individual courses and hours? Should we not rather think of it in terms of its larger components which, in the opinion of the Board, are three: the element of liberal or general studies, the element of the fundamental sciences, and, in the third place, the element of strictly practical and technical studies. The element of economic studies will of course enter into all three of these groups. The Curricula of all our engineering schools are too crowded. A good case could probably be made for every one of the multitudinous courses given in all of our engineering schools. The details are good, but the total result is not quite satisfactory. Something more than good bricks are necessary to the building of a good building. It may fairly be argued, in the opinion of the Board, that the problem of the engineering curriculum has not been solved largely because engineering professors think not in terms of engineering education but rather in terms of their own subject and the specific courses in which they are interested. A larger view which will take into consideration what the student does before he comes to the engineering school and which will leave something for him to do after he leaves is necessary if this vexed problem of the curriculum is to be solved.

The second problem which we have to present to you is that of the social and economic content of the engineering course. Bound up with this is the whole problem of the relation of the engineer to society. It is a problem which every other profession has had to face and which engineering cannot possibly evade. It is no small part of the justification of the fact that in law and medicine an academic degree is required before the candidate enters upon the specific training for his life work. Can it be solved within the limits of the much shorter course followed by the student of engineering? It would seem to be evident that it cannot unless much more careful thought than we have ever given it in the past is devoted to the selection and preparation of the teaching material.

The third of the six topics which we are going to ask you to discuss tomorrow is the problem of admissions. For the

vast majority of engineering schools a system of admission by certificate is now in vogue and seems likely to remain. But it is quite clear that admission by certificate alone does not result in the selection of the ideal student body for an engineering school. The question is how it can be improved —how the selective principle can be introduced. Can this be done by requiring grades above the mere passing mark in secondary work in certain subjects, say Mathematics, English, and the Sciences? Can it be done by the use of so-called intelligence tests or by tests designed to discover specific aptitude for engineering work? These are problems which we shall ask you to discuss. It seems quite clear to the Board that the important thing is to introduce by some means the principle of selection. If that principle can be introduced, it will undoubtedly result at first in some reduction of numbers and in marked improvement in undergraduate work. The first requisite for a good engineering school, as for a good school of any other type, is a good student body. If the level of ability in all our engineering schools were as low as the lowest twenty-five per cent, most of us would have very little interest in engineering education, and the leaders in the engineering profession would have to be chosen from somewhere else. On the other hand if all the students in all our engineering schools were as good as the best twenty-five per cent, it would be hard to set a limit to the influence of the profession of engineering in the next generation.

The fourth topic which we shall ask you to discuss is the problem of the non-graduating student. We have him with us in large numbers, and no matter how effective our admissions procedure may be made we shall probably have him for some time to come. We get into our engineering schools a certain proportion of students who are intellectually unequal to the work; we get a certain number who are intellectually able but who do not have specific engineering aptitude. These last can perhaps be transferred to the liberal arts course. The serious problem is what to do with the first. In many cases they have a certain aptitude for the minor grades of engineer-

ing work. It is a serious question whether there should not be provided for them some form of certificate which would be accepted for work of that kind and which would facilitate their entrance into the engineering world in the grades of work for which they are fitted. It is a great question, which we shall ask you to consider seriously, whether their number ought not to be increased and whether the bar to entrance into the junior class in our engineering schools should not be made much higher than it is at present.

The inferior student presents one problem, the superior student another and that no less difficult. We should like to have you discuss tomorrow in the fifth place whether our engineering courses as at present organized do not do serious injustice to the best and ablest students. Do we not run the risk of killing their intellectual interests by holding them back to a pace with which the average man can keep up? Is it possible for us to give them such an education as they deserve unless we can so arrange our courses as to demand from them the best work which they are able to do? Should we not section our elementary courses on the basis of ability, and should we not differentiate largely in advanced work between the minority who are capable of making good use of much more freedom and who are capable of meeting much higher standards instead of herding them with the majority for whom our present methods are moderately successful.

Of equal importance is the last problem which we are proposing to you, that of teaching personnel. It is a problem which engineering schools as a group hitherto have not faced. An engineering professor is like Topsy; he has "just growed." If we are to have better engineering education, how are we to recruit the body of better teachers necessary for it? How are we to train them? What training do they need? How are we to adjust their compensation so as to make the teaching of engineering attractive or even possible for the men who are to do it? What is a fair load for a teacher of engineering? How much teaching should we expect him to do? How much should we expect of him in the form of the practice of his pro-

fession or of contribution to engineering knowledge? These are difficult problems, but they will never be solved until they are faced.

It is the hope of the members of the Board that in your discussion tomorrow you will deal with principles rather than with details. If you have imagination, prepare to use it now. We are all of us teachers, and we may confess among ourselves that a certain element of pedantry is hardly to be escaped in the case of a man who has given his life to a pedagogical endeavor. I am not an engineer myself, but I have spent a good many years of my life in contact with engineers and with engineering teachers. If there is any profession in which pedantry has no place it is in engineering, and we can hardly do justice to the great vocation in which we are interested unless we can rise above prejudices of localities and of departments to a consideration of the principles of engineering education as a whole.

It is a well known fact that the great professions of law and of medicine were centuries in rising to their present intellectual status and to the high level of professional ethics and professional spirit which animate them at their best. Professional spirit seems to me the highest manifestation of modern civilization. At its best it is the spirit of trusteeship. The professional man is a trustee for those interests of his client which lie within his particular province. He places this devotion to his client's interest above his own private advantage, often above what the client may think his own best interests. The professional man is also a trustee of a body of knowledge. He is interested in the education for his profession because he wishes that knowledge to be made of the maximum service to society. He is interested in increasing that knowledge and in spreading it abroad for the same reason. The medical man is primarily interested in telling you how not to be sick, and your legal adviser in drawing your contracts so that they will not become the subject of litigation. Something of the same kind of spirit is necessary to the upbuilding of any great profession. And the rapid way in

which it is spreading, so that something like a code of professional ethics is coming to animate the practice of almost every occupation, is perhaps the most striking moral phenomenon of the modern world. To us who are responsible for the education of the men who will constitute the engineering profession of the next generation is entrusted the task of building up such a spirit. We are trustees seeking to learn the wisest way in which to fulfill our trust.

I am not an engineer but I know teachers of engineering and I know that you are not met here primarily to devise a curriculum. You are not here primarily to get pointers for the success of your particular engineering school or your particular branch of engineering. You are not here to learn the latest and best advertised tricks of teaching nor to help students to merely individual success. You are met rather to study and to consider and discuss the best methods of laying the foundations, both scientific and moral, of a great profession which will enable your graduates to make better use of the sources of power in nature for the upbuilding of civilization.

THE ENGLISH DEPARTMENT.

The ideal, so clearly stated in the latest report of the Board of Investigation and Coördination, of an integrated, coördinated course of instruction which shall aim at the all-round development of the student, is one that concerns vitally the teacher of English to engineering students. The time is evidently past when any maker of engineering curricula imagines that the inclusion of a course or two of English will somehow, in a magical way, humanize the whole scheme of technical studies. That was the crude excuse given when it seemed first necessary to justify the place of English in the curriculum. The lofty notion later found utterance that if only all the subjects taught were presented by men of broad humanistic consciousness, with background, and a vision of the wide applications and the varied relationship of the subjects taught, the spirit of the humanities might somehow be breathed into the body of technical studies. This high ideal is still well worth cherishing, but evidently, judging from the evidence of the report of the Board, it is not to preclude the insistence on such subjects as are specially fitted by their content to stimulate the human interest, and social sense, and to develop appreciation and taste, and to train the reason and judgment. And among these means for influencing the personality of the student, English composition and English literature and training in English speech are specifically included. They are included, as they have been, as elements in the curriculum, but with this new, important emphasis. They must be correlated more closely with the other elements; they must be an integral part of the school experience of the student, which shall fit him ultimately to take his place intelligently in society as well as in his profession.

Since this is the ideal which the Committee on English has held from the now distant days when Professor Earle of Tufts was its chairman, it will be glad now to point out concrete

ways to realize for English a more effective place in the scheme of Engineering education.

In the first place, there is danger that the beginning course in English, whatever it be called, or by whomever it is taught, shall be regarded as a disagreeable task to be got through with as well as may be. Teachers and students alike often regard it with distaste, and certainly neither often appreciate its importance. Such work needs to be vitalized and motivated by a clear recognition of the student's special interests, a sympathy with his point of view, an intelligent appreciation of the limits of his patience and of his possibilities. Since our engineering students have a common objective and aim, it is easier for even the unskilled teacher to find these important bases for the method of his presentation, if the students are taught in a homogeneous group. On its practical side, a freshman English course may do much, beside merely providing the much needed practice work in writing, by giving some guidance and direction and criticism of the student's method of taking and filing his lecture notes. Here is a very definite correlation with his immediate needs. The oral work well stress both speech correction, the social and professional value of which every student can be made to appreciate, and a good oral expository method as a necessity for his recitation work. Two more important correlations. The inclusion of some training in letter writing in this first course gives the student help where it is often greatly needed.

Finally, if the work in English literature which is included in this first year's work is skillfully and tactfully chosen, with due effort to enlist the enthusiasms of the student, and to allay those prejudices with which he often faces such work, it may result in the reading habits which may stand him in good stead as a means of wholesome recreation and effective self-development. These are some of the contributions which English work may make to the development of the freshman student. If, as in some colleges, the freshman English course can be correlated with the freshman assembly, or with orientation courses which aim to adjust the student to his new en-

vironment, or to clarify his vision of his objectives, so much the better. The point is, that if English is to be an integral and indispensible element in the curriculum of the first year, it must not be thought of by either teacher or student—and certainly not by the dean—as a course, but as a developmental experience—a splendid opportunity to stimulate the growth of new habits of thought and expression which should have an immediate and a permanent value.

In the second place, the report of the Board of Investigation specifically indicates the importance of a vertical rather than a horizontal arrangement of studies in the curriculum,—"a band of humanities extending throughout the length of the course." This is certainly consistent with the idea of a natural and progressive development of the student as a personality as well as a prospective engineer. Unfortunately in many colleges the student "gets off his English" in his first two years at the latest; he thinks of English as something finished and done for.

Ideally, his training in expression should progress simultaneously with the broadening of his range of ideas to be expressed. He should have guidance and criticism as he is forced to apply to new fields of thought the principles of exposition he has acquired in his beginning courses. His interest in books should be stimulated and directed somewhat. His taste should be refined and his critical judgment made more sure. Some scheme of English training should be so integral a part of his course that at no time during the four years should he escape some of these essential influences.

In several colleges with which I am familiar, this integration of English with the entire four years has been quite effectively worked out. In most the situation is still more or less experimental. In none has been achieved, of course, the ultimate realization of this ideal. Since this is the case, I venture, as a means of making the idea concrete, to outline what might be at least one way of providing for a progressive and continuous relation of English to the four year curriculum.

The ideal requirements would be sixteen hours of English, distributed as follows:

In the freshman year, two three-hour courses, one each semester. These courses would be combination of composition, literature, and public speaking.

In the sophomore year, two two-hour courses, largely in the appreciation of English literature, rather than in its history or in detailed technical criticism. It is highly desirable that in his sophomore year the student have several courses in English literature from which to choose his four hours.

In his third year, every student should be required to choose from a list of attractive advanced courses in English literature, a two-hour course, and in his fourth year another two-hour course.

Finally, in his senior year, each student should be required to take some substantial course in English composition, which, if possible, should be correlated closely with his senior technical work.

This means, to be sure, sixteen hours of English, but one wonders how sixteen hours could be better spent, if as engineering educators we are sincere in our desire to send our boys out with the interests and tastes of educated men, with the ability to speak and write as if they had really been for four years under the influence of university training.

At this point I can hear my friends the deans saying things, some of them under their breath, and some of them dramatically, full voice. To many of them what I have said must seem quite impractical. Of course it can be done; it has been done, but I hasten to remind them that I have been indulging in a comment on the ideal. The problems which this ideal entails are largely those which only the administration of the college can solve. Time, teachers, finance! How chimerical that sixteen-hour requirement seems. And of course the task of finding teachers of real vision, of genuine enthusiasm, willing to identify themselves with engineering education is, under present conditions, rather appalling. But if the report of the Board of Investigation and Coördination is to be taken

as serious evidence of the trend of engineering education, it is in some such way as this that English must be integrated with the whole scheme of engineering studies.

Correspondence on this general subject is solicited by the Committee on English. Address J. Raleigh Nelson, 927 Forest Ave., Ann Arbor, Michigan.

SECTIONS AND BRANCHES

The Kansas-Nebraska section, including the universities of Kansas and Nebraska and the Kansas State Agricultural College, held its annual meeting at Lincoln, Nebraska, on the 12th and 13th of November.

For the first time the wives of the members were invited and entertainment provided for them.

At a 6:30 dinner provided by the Nebraska group there were ninety present, including the women. The dinner was followed by a lecture by Dr. H. B. Alexander on the art features of the new Nebraska State Capitol.

The entertainment for the evening consisted of a theater party for the women and a technical session for the men.

This session was called to order by the chairman, Professor Geo. C. Shaad.

The subject for discussion for the evening was "Freshman Week." Professor Tait, of Kansas, led the discussion, followed by Professor Conrad of the Kansas State Agricultural College and Professor Hendricks of Nebraska, followed by a general discussion of the advantages and disadvantages of Freshman Week. The members were very divided in opinion on the value of such a week with most members probably favoring at most a two-day period.

The subject "Economics for Engineering Students" was discussed at the morning session.

Professor Hollister, of Nebraska, led this discussion. The members were quite agreed on the advisability of the teaching of economics to engineering students, also on the extent to which it should be taught.

At the close of the program Professor L. E. Conrad, of the Kansas State Agricultural College, was elected president for the section for the coming year, Professor O. E. Edison, of the University of Nebraska, secretary, and Professor F. L. Brown, of the University of Kansas, chairman of the program committee.

After an expression of appreciation of the hospitality shown

the visitors, the meeting adjourned for a drive about Lincoln and for a visit to the State Capitol building.

A very fine dinner given by the hosts at the Lincoln Chamber of Commerce was attended by sixty-eight members. Seventeen women attended a dinner given also at the Lincoln Chamber of Commerce building.

These sectional meetings are rapidly gaining in interest and attendance.

A fine feature of these meetings is the quarters provided for the visitors. Cots, blankets, sheets and pillows were furnished in classrooms and laboratories. All the conveniences of camp life, without its inconveniences, were thoroughly enjoyable and good fellowship was promoted.

A meeting of the **Minnesota Section** of the S. P. E. E. was held November 9, 1926, at 5:45 P.M. at the Campus Club with President Martenis presiding. About 60 members and guests were present to hear Professor E. Hudelson's paper on "Class Size and Student Achievement." A lively discussion followed the presentation of Professor Hudelson's paper. An abstract of the main address and the discussion which followed is given herewith.

President Martenis announced the appointment of the following committees for the year: *Program Committee:* J. H. Kuhlman, Chairman, G. C. Priester, C. F. Shoop.

Nominating Committee: W. H. Kirchner, Chairman, C. A. Mann, J. I. Parcel.

G. B. Heisig,
Secretary.

Proposed Greater New York-New Jersey Section.—An organization meeting of a local section of the Society, to include Greater New York and New Jersey will be held at Columbia University on the afternoon and evening of Saturday, January 22, 1927. The afternoon session will be devoted to a brief business meeting followed by the presentation and discussion of the first installment of the final report of the Board of Investigation and Coördination. Director W. E. Wickenden will present the report and introduce the discussion.

The afternoon session will be followed by a visit of inspection to the engineering laboratories and the recently completed chemistry and physics buildings of the University.

A dinner will be held at the Columbia University Faculty Club at 6:30 P.M. Following the dinner there will be a brief business session, a smoker, and a round-table discussion of two topics: (1) What should be the relation of the engineering colleges to the educational and vocational guidance of secondary school students? The discussion will be introduced by Professor Harry D. Kitson of Teachers' College, Columbia University, and Principal Herbert L. Colston of the Brooklyn Technical High School. (2) Do the institutions of the metropolitan area properly capitalize the possibilities of their environment? This topic will be introduced by Professor E. F. Church, Jr., of the Polytechnic Institute of Brooklyn and Professor Walter Rautenstrauch of Columbia University.

The sponsors of the Section are:

Alex C. Humphreys, President, Stevens Institute of Technology.
Parke R. Kolbe, President, Polytechnic Institute of Brooklyn.
Arthur M. Greene, Jr., Dean, Princeton University, Past-President, S. P. E. E.
George B. Pegram, Dean, Columbia University, Past-President, S. P. E. E.
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Charles H. Snow, Dean, New York University.
W. E. Wickenden, Director of Investigation, S. P. E. E.
W. O. Wiley, John Wiley & Sons, Treasurer, S. P. E. E.

COLLEGE NOTES.

Syracuse University.—The Faculty of the College of Applied Science of Syracuse University has voted to abolish the degrees of Civil Engineer, Electrical Engineer and Mechanical Engineer, and will hereafter award degrees of Bachelor of Science in the fields of Civil, Electrical and Mechanical Engineering.

Dr. Albert Salathe has been appointed Associate Professor of Chemical Engineering. Dr. Salathe is a graduate of Colgate University and received his Ph.D. degree from the University of Chicago. He was formerly on the faculty of Union College and of Centenary College. He will take up his duties at Syracuse at the beginning of the second semester, February 1.